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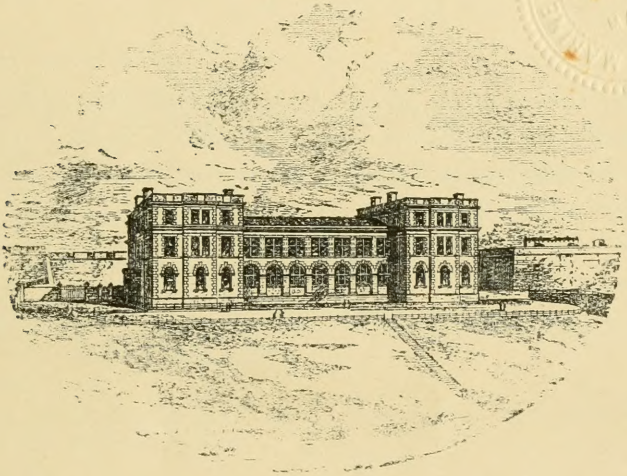

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CONTENTS OF VOLUME VIII.

(NEW SERIES.)

The Fishes collected by the "Huxley" from the North Side of the Bay of Biscay in August, 1906.

By

L. W. Byrne.

With one Figure in the Text.

ONLY one species met with on this cruise appears to have been previously undescribed.

Although all the other species were already known from similar localities in the North-east Atlantic, attention may be called to an interesting series of the young of *Synaphobranchus pinnatus* and to the capture of numerous young examples of *Onus biscayensis.*

When compared with the results of the hauls taken by H.M.S. *Research*, a little farther south and over very much deeper soundings, the list of species taken by the *Huxley* is chiefly remarkable for the entire absence of *Stomias boa, Gonostoma microdon,* and *G. bathyphilum,* the range of none of which seems to extend into waters as shallow as those fished by the *Huxley.*

STOMIATIDAE.

Maurolicus borealis, Nilsson.

The small fish trawl took two damaged larvæ (about 7.5 mm. long) at Station VIII.* and very many young, one of 27 mm. and 98 others of all sizes between 20 and 12 mm., at Station X.

ANGUILLIDAE.

Conger vulgaris, Cuv.

A *leptocephalus* of this species (kindly identified for me by Dr. Schmidt) 141 mm. long was taken in the small fish trawl at Station VIII.

SYNAPHOBRANCHIDAE.

Synaphobranchus pinnatus, Gthr.

Fourteen specimens, 105 to 270 mm. in length, were taken at Station XII., on fine sand at a depth of 246 fathoms.

This series serves to connect the small specimen taken by the *Helga* (Fisheries, Ireland, *Sci. Invest.,* 1905, ii. [1906]) with examples having

* For the positions of the Stations see Table on p. 5.

the form and characters of the adult, and dispels any doubt as to the correct identification of the former specimen.

The relative distance of the origins of the dorsal and anal fins from the snout is subject to considerable individual variation; and the length of the head is contained $2\frac{1}{2}$ to $3\frac{1}{4}$ times in the distance from the snout to the origin of the dorsal fin, 2 to $2\frac{1}{4}$ times in the distance from the snout to the origin of the anal fin, and half to slightly more than once in the interval between the origins of the two fins, which is relatively shortest in the two smallest examples.

The belly of the smallest specimen, 105 mm. long, was distended by the vertebra of another fish about 4 mm. long and 3 mm. in diameter, to which fragments of flesh still adhered.

Scopelidae.

Scopelus (*Myctophum*) *glacialis*, Reinhdt.

Nine specimens, 38 to 12 mm. in length (without caudal fins) were taken at or near the surface at Station VIII.

S. (*M.*) *punctatus*, Raf.

Ten specimens, 37 to 20 mm. in length (without caudal fins), were taken in the same haul as the last species. In these specimens the superanal photophores numbered 7–9 + 8–10, and the posterolateral varied somewhat in position, being either above the break in the superanal series or above the last photophore anterior to the break.

S. (Lampanyctus) crocodilus, Risso.

A single damaged specimen 21 mm. long (without caudal fin) was taken in an Agassiz trawl at Station XII. There is nothing to show the precise depth at which it entered the net.

The small fish trawl at Station X. contained the remains of *Scopelus* larvæ, too broken for specific determination.

Paralepis sp.

"*Long-anal*" *larva.* Holt & Byrne, *Trans. Linn. Soc.*, x. p. 199.

A damaged specimen about 29 mm. long from Station X.

Syngnathidae.

Nerophis aequoreus, *var. exilis*, H. and By., was taken by the small fish trawl, worked as near the surface as possible, at Stations VIII. (nineteen; 177–43 mm.) and X. (two; 220 and 105 mm.). The smallest ovigerous male captured was 150 mm. long.

Gadidae.

Phycis blennioides, Brunner.

Nine specimens (145 to 85 mm. long) were taken at Station IX. on

fine sand in about 240 fathoms of water, and a single specimen (108 mm. long) at Station XII. on similar ground at about the same depth.

Onus sp.

Six specimens of a tricirrate *Onus* from 60 to 109 mm. long from Station VII. cannot at present be satisfactorily referred to any described species and, in view of the difficulties attending the satisfactory determination of isolated specimens belonging to this genus, it seems best to await further material before applying any name to them.

Drs. Schmidt and Jensen have kindly compared the specimens with *O. Reinhardti* of a comparable size, and inform me that they certainly do not belong to that species, while they also appear to be distinguishable from *O. Carpenteri*, Gthr., and *O. macrophthalmus*, Gthr.

The specimens were taken with the Agassiz trawl, which came up filled with large masses of coral.

Onus biscayensis, Collett.

Small examples occurred as follows, in each case on sandy ground:

Station II.—One, 61 mm.
Station IX.—Two, 62 and 54 mm.
Station XIII.—Seven, 64 to 48 mm.

The broken remains of two small fishes from Station XIII. are probably referable to either this or the preceding species.

Specimens of the size captured appear to have the back ordinarily greyish-brown in colour with obscure marblings of a darker shade which become less conspicuous with growth.

PLEURONECTIDAE.

Arnoglossus laterna (Walb.).

Two specimens, 89 and 40 mm. long, at Station II. (75–80 fathoms), and two, 140 and 37 mm. long, at Station XI. (146 fathoms).

The larger example taken at the latter station showed the character of "*A. lophotes.*"

Zeugopterus megastoma (Donov.).

A single specimen of 175 mm. at Station II. and three smaller ones (73–53 mm.) at Station XI.

Damaged larvæ (about an inch long in each case) were taken by the small fish trawl at Stations VIII. (one) and X. (one).

Solea variegata (Donov.).

A single specimen, 110 mm. long, at Station VIII.

GOBIIDAE.

Gobius Jeffreysii, Gthr.

A single specimen of 21 mm. at Station X. and fourteen others of 32 to 20 mm. at Station XI.

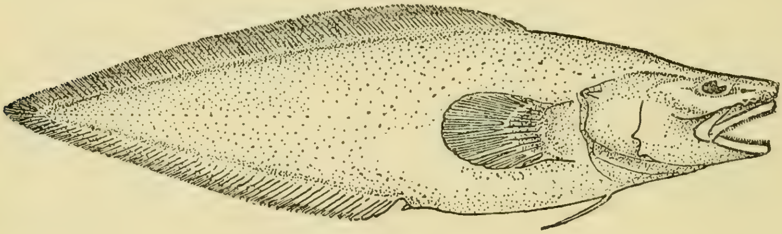
Lycodidae.

Pteridium Alleni, Byrne.*

The specimen on which this species was founded was taken at Station VII. in about 444 fathoms. The specimen was taken with the Agassiz trawl, which came up filled with large masses of coral.

The original description and sketch of this species are (by the kind permission of the editor of the *Annals and Magazine of Natural History*) repeated below:—

Form stout; body compressed in caudal region, its greatest height about 4 times in its length (without caudal fin). Head depressed, $3\frac{1}{2}$ times in length (without caudal), nearly twice as long as broad, its breadth about equal to its height at isthmus. Snout rounded, with numerous mucous glands, about $4\frac{1}{4}$ times in head. Eye of moderate size, longer than the flat interorbital space is wide, 6 times in head and less than $1\frac{1}{2}$ times in snout. Gape $2\frac{3}{5}$ times in head, barely reaching



Pteridium Alleni, × 1.

beyond the level of the hind margin of orbit; maxilla weak, and but little expanded distally. Villiform teeth in both jaws and in a **V**-shaped band on vomer.

Marginal fins continuous, their bases covered with skin and scales; fin-rays difficult to count, probably D. *ca.* 90, A. *ca.* 55. Ventrals each with two closely apposed rays.

Body covered with a copious mucous secretion; scales very small, approximately 105 in a longitudinal and 35 in a transverse series. Lateral line very indistinct and broken.

Colour, after preservation, umber-brown, darker on top of head and front part of dorsum, paler on belly. Rays of marginal fins dark.

Length of type, 101 mm. (96 mm. without caudal).

Hab. Mouth of English Channel, near La Chapelle Bank, *ca.* 450 fath.

* *P. Alleni*, Byrne, *Ann. Mag. Nat. Hist.*, Ser. 7, vol. xviii. p. 448 (Dec., 1906).

Station No.	II.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.
Latitude, N.	48° 24′	47° 36′	47° 30′	48° 7′	48° 7′	48° 10′	48° 7′	48° 7′
Longitude, W.	6° 28′	7° 31′	7° 31′	8° 13′	8° 13′	8° 11′	8° 13′	8° 13′
Fathoms	75	444	Surface.	240	Surface.	146	246	412
STOMIATIDAE.								
Maurolicus borealis	–	–	2 l.	–	99	–	–	–
ANGUILLIDAE.								
Conger vulgaris	–	–	1 l.	–	–	–	–	–
SYNAPHOBRANCHIDAE.								
S. pinnatus	–	–	–	–	–	–	14	–
SCOPELIDAE.					4 l.			
Scopelus glacialis	–	–	9	–	–	–	–	–
,, punctatus	–	–	10	–	–	–	–	–
,, crocodilus	–	–	–	–	–	–	1	–
SYNGNATHIDAE.								
N. aequoreus v. exilis	–	–	19	–	2	–	–	–
GADIDAE.								
Phycis blennioides	–	–	–	9	–	–	1	–
Onus sp.	–	6	–	–	–	–	–	2 ?
,, biscayensis	1	–	–	2	–	–	7	–
PLEURONECTIDAE.								
Arnoglossus laterna	2	–	–	–	–	2	–	–
Zeugopterus megastoma	1	–	1 l.	–	1 l.	3	–	–
Solea variegata	1	–	–	–	–	–	–	–
GOBIIDAE.								
Gobius Jeffreysii	–	–	–	–	1	14	–	–
LYCODIDAE.								
Pteridium Alleni	–	1	–	–	–	–	–	–

The Alcyonaria, Antipatharia, and Madreporaria collected by the "Huxley" from the North Side of the Bay of Biscay in August, 1906.

By

Sydney J. Hickson, M.A., F.R.S.

(Professor of Zoology in the Victoria University of Manchester.)

The principal feature of interest in these collections is the presence of a single fine specimen of *Corallium maderense.* Only one other specimen of this species has hitherto been obtained, and no specimen of the family has hitherto been recorded from the Bay of Biscay.

The occurrence of *Sympodium coralloides* in the Bay is also a feature of some interest, but not very surprising, as it is in other localities usually associated with the Madreporarian corals on which it was found.

ALCYONARIA.

Family ALCYONIIDÆ.

Alcyonium coralloides, Pall.

Gorgonia coralloides, Pallas, *Eleuch. Zoophyt.*

Alcyonium coralloides, von Koch, *Zool. Jahrb.*, v. 1891, p. 76.

Sympodium coralloides, de Lacaze Duthiers, *Archiv. de Zool. Expér.*, 3°, viii. 1900, p. 360.

Station VII. Lat. N. 47° 36′. Long. W. 7° 31′. $\frac{\cdot}{444}$ fathoms.

A few small specimens evidently belonging to the white variety of this species are found encrusting the dead bases of the Oculinid corals. None of the specimens are large enough to enable me to reopen the question whether the species belongs to the genus *Sympodium* or the genus *Alcyonium.* Notwithstanding the very able discussion of this question by de Lacaze Duthiers, who retains the species in the genus Sympodium, I am inclined to consider the reasons given by von Koch for transferring it to the genus Alcyonium as unanswerable. In any case, it is an extremely interesting connecting link between the Stolonifera and the Alcyonacea. In the Mediterranean Sea the

spicules are usually purplish red to pale pink in colour, but, according to de Lacaze Duthiers, pure white varieties also occur.

The species was not recorded from the Bay of Biscay either by the *Caudan* or the *Hirondelle* expeditions.

Alcyonium digitatum, Linn.

STATION I. Lat. N. 48° 25′. Long. W. 6° 28′. 75 fathoms.

A small white unbranched specimen of this species was obtained at this station. It is noteworthy that no specimens of the species were found in the dredgings in deeper water. The *Caudan* expedition obtained the species at a depth of 570–600 metres.

FAMILY **CORALLIIDÆ.**

Corallium maderense, Johnson.

Pleurocorallium maderense, J. Y. Johnson, *Proceed. Zool. Soc., London*, 1899, p. 60, Plates V. and VII., figs. 1 and 4.

STATION XIII. Lat. N. 48° 7′. Long. W. 8° 13′. 412 fathoms.

The type of this species was obtained by Rev. Padre Ernesto Smith, to whom it was given by a fisherman, who told him it was brought up by a fishing-line from deep water off Camara de Lobos, a village six miles to the west of Funchal. No other specimen of the species has been described. The species was placed in the genus *Pleurocorallium* by Johnson, but for reasons pointed out by Kishinouye (*J. Imp. Fish. Bureau*, xiv. 1, 1904), which I can confirm by my investigations on the Coralliidæ of the *Siboga* expedition, to be published shortly, it is inconvenient to subdivide the known species of the Coralliidæ into generic groups, and I have therefore referred it to the genus *Corallium*.

The specimen is 110 mm. in length, flabellate in growth, with the verrucæ all on one side of the colony and about 70 mm. in width. The main axis is kidney-shaped in section, 6 mm. × 4·5 mm. The base of attachment is broken off and the ends of many of the branches are missing, and consequently it may have been a good deal larger when in position at the bottom of the sea. The type specimen was considerably larger than this, being 300 mm. in length and about the same in width. The specimen resembles the type in all essential respects. The ramification is not quite so profuse, and there are not so many of the "double carafe" or "opera-glass-shaped" spicules as described by Johnson, but I can find no substantial reason for making a new species.

It is perhaps the most interesting feature of the collection of Anthozoa that has been sent to me for examination to find a specimen

of *Corallium* in the Bay of Biscay. No specimens of *Corallium* were found by the *Challenger*, *Lightning*, *Porcupine*, or *Caudan* expeditions in their explorations of the deep-sea fauna of the west coasts of France and the British Islands, but a single specimen of *Corallium johnsoni* was obtained by the Irish Fisheries Department in 382 fathoms off the west coast of Ireland (Hickson, *Nature*, vol. 73, 1905, p. 5, and *Fisheries, Ireland Sci. Invest., 1905*, v. [1906]). It is established therefore that *Corallium* does occur on the Atlantic slope of the European shores, but it is apparently very rare, or else very local in its distribution. The axis is pure white, but very hard and somewhat translucent. The coral is not of a character to command a high price, but it is possible that if a locality could be found where it occurs in considerable quantities the thicker branches would have a market value.

A series of sections through a small branch shows that the colony is female, but the ova are not, I believe, nearly mature.

Like all the other species of the genus that have been examined, *C. maderense* is dimorphic. The ova are borne by the siphonozooids and not by the autozooids. In this respect the species differs from *C. nobile*, in which the gonads are borne by the autozooids only, and resembles *C. japonicum*, *C. konojoi*, *C. elatius*, and *C. reginæ*.

Family **ISIDÆ.**

Isidella elongata, Gray.

Isidella elongata, Gray, *Cat. Lithophytes*, 1870, p. 14.

Isis elongata, Esper (see von Koch, *Fauna and Flora, Naples*, Monog., xv. 1887, p. 90, plates and figures).

Station XIII. Lat. N. 48° 7′. Long. W. 8° 13′. 412 fathoms.

The name of this species has been subject to many changes, and it would form an interesting subject for a specialist in such matters to determine which, according to the rules of nomenclature, is the correct one. It was described as a new species by von Koch in 1878 (*Morph. Jahrb.* iv. 126), by the name *Isis neapolitana*. In 1882 he changed the name to *Isidella elongata*, Esper (*Mitt. Zool. Stat. Neapel*, bd. iii. 537). In 1887 it is described by the same author as *Isis elongata*, Esper, but in a "Nachtrag" is referred back again to the genus *Isidella*. I am in agreement with Wright and Studer (*Chall. Reports*, xxxi., 1889) in thinking it is doubtfully synonymous with *Isis elongata* of Esper, but it may be the same as *Mopsea elongata* of Philippi and *Mopsea mediterranea* of Risso. There can be no doubt, however, that it is the same as the *Isidella elongata* of Gray, and for that reason I have attributed the species to him. The species was obtained by the

Caudan in 5° 55′ W., 46° 40′ N., 400–500 metres. The specimen is 200 mm. long, and gives off one slender branch 100 mm. from the base. The axis is 2 mm. in diameter at the base, and tapers gradually to a very slender filamentous thread at the extremity. The internodes are from 10 to 15 mm. in length.

Acanella arbuscula, Johnson.

Mopsea arbusculum, Johnson, *Proc. Zool. Soc.*, 1862, p. 245, Pl. XXXI. figs. 1, 1a.

Acanella arbuscula, Gray, *Cat. Lith.*, 1870, p. 16, woodcut.

Station XIII. Lat. N. 48° 7′. Long. W. 8° 13′. 412 fathoms.

This is a characteristic species of the Atlantic slope. It was first described by Johnson from Madeira. It was found by the *Challenger* in 1525 fathoms S.W. of the Canaries. It was found in no less than four stations at depths of from 950 to 1710 metres in the Bay of Biscay by the *Caudan.*

Being very brittle owing to the alternating calcareous and horny joints of the axis, the specimens always reach the systematist considerably broken.

In the *Huxley* collection there is a main axis with nearly all the branches broken off that is 150 mm. in length, the calcareous internodes 10 mm. in length, and the greatest diameter of the stem 5 mm.

The most perfect "bushy part" of a colony is 105 mm. in height by 55 mm. in diameter.

Family **MURICEIDÆ.**

Acanthogorgia ridleyi, Wright and Studer.

A. ridleyi, Wright and Studer, *Challenger Reports*, vol. xxxi. 1889, p. 95, Plates XXII. and XXV.

Station VII. Lat. N. 47° 36′. Long. W. 7° 31′. $\frac{\cdot}{444}$ fathoms.
1 specimen.

Station XIII. Lat. N. 48° 7′. Long. W. 8° 13′. 412 fathoms.
5 specimens.

I have had a great deal of difficulty in determining the species of the specimens of *Acanthogorgia* obtained by the *Huxley.* A great many species of this genus have been described by authors, and in most cases from the examination of a single specimen. There is no account of the range of variation within the limits of a single species. There can be little doubt, I think, that when the genus is overhauled the number of species will be materially reduced. Having compared our specimens with the species in the British Museum, I have found

that they resemble very closely those attributed to *Acanthogorgia ridleyi* obtained by the *Challenger* off Patagonia.

This species was also discovered by the *Caudan* expedition at their station 6° 21′ W., 45° 47′ N., 1410 metres. The species obtained by the *Hirondelle* expeditions from the Golfe de Gascoyne are attributed by Studer to *A. truncata* and *A. horrida*, but these came from much shallower water (240 metres and 200 metres respectively). The spicules are much larger than those of the type of *Acanthogorgia ridleyi*, and resemble more closely the spicules of *A. muricata*, Verrill. The longest of the bent spindles are 1·2 mm. in length. In the other three species they do not attain to a length of 1 mm. There is another difference between our specimens and the type in that on many of the branches the zooids are very closely crowded together, especially at their extremities, instead of being separated by intervals of 3–4 mm. The observations I have made on a small piece of a branch of one of the type specimens do not quite agree with the description given by Wright and Studer, and in so far as they differ, agree more closely with our specimens. On comparing them I have come to the conclusion that they cannot be regarded as anything but varieties of the same species.

I may add, in conclusion, that I have compared our specimens with a small dried piece of *Acanthogorgia* (*Blepharogorgia*) *schrammi* of Duchassaing and Michelotti, and find them to be closely related.

THE ANTIPATHARIA.

FAMILY **ANTIPATHIDÆ.**

Stichopathes spiralis, Pourtalès.

Antipathes spiralis, Pourtalès, *Bull. Mus. Comp. Zool.*, 1880, p. 114, Pl. III.

Stichopathes pourtalesi, Brook, *Challenger Reports*, xxxii. 1889, p. 89.

STATION VII. Lat. N. 47° 36′. Long. W. 70° 31′. $\frac{\cdot}{444}$ fathoms. 2 specimens.

STATION XIII. Lat. N. 48° 7′. Long. W. 8° 13′. 412 fathoms. 4 specimens.

This species was obtained by the *Caudan* at Stations IV. and X., in 1410 and 1220 metres respectively.

Parantipathes larix, Esper.

Antipathes larix, Esper.

Parantipathes larix, Brook, *Challenger Reports*, vol. viii. 1889, p. 142.

STATION XIII. Lat. N. 48° 7′. Long. W. 8° 13′. 412 fathoms.

There are six specimens in the collection, varying in length from 225 mm. to 325 mm. The species was obtained by the *Caudan* in 1220 metres.

FAMILY **SCHIZOPATHIDÆ.**

Schizopathes crassa, Brook.

STATION XIII. Lat. N. 48° 7′. Long. W. 8° 13′. 412 fathoms.
1 specimen.

Schizopathes crassa, Brook, *Challenger Reports*, xxxii. p. 147.

This species was originally found by the *Challenger* in 1900 fathoms off Monte Video, but it was subsequently discovered by the *Caudan* at Station XVI., 5° 53′ W., 45° 38′ N., in 1220 metres.

The specimen is broken at the base, and is about 530 mm. in total length. The lateral branches arise sometimes in pairs, sometimes alternately, sometimes irregularly, from a strip of about one-third the width of the total circumference of the main axis, and are in two series, inclined at an angle of about 30° to each other. The lateral branches in the middle region are 250 mm. in length, those at the distal end very much shorter. At the proximal end the branches are broken.

The zooids seem to be about the same size as the type specimen, that is about 3 mm. in a diameter transverse to the axis, but the tentacles are much more contracted than those of the *Challenger* specimen, and are not more than 3 mm. in length (cf. 4–7 mm. in the type).

The character of the spines on the axes corresponds with the description of the type. Although there is a difference in the manner in which the lateral branches arise from the main stem between the *Huxley* and *Challenger* specimens, there is no good reason, in my opinion, for regarding them as distinct species.

The species was also found in the Bay of Biscay in 1220 metres by the *Caudan*.

THE MADREPORARIA.

FAMILY **TURBINOLIIDÆ.**

Caryophyllia clavus, Scacchi.

Caryophyllia clavus, de Lacaze Duthiers, *Archiv. de Zool. Expér.*, 3°, v. 1897, p. 37, and 3°, vii. 1899, p. 529.

STATION I.	Lat. N. 48° 25′.	Long. W. 6° 28′.	75 fathoms.
STATION II.	Lat. N. 48° 24′.	Long. W. 6° 28′.	75 fathoms.
STATION V.	Lat. N. 47° 48′.	Long. W. 7° 46′.	109 fathoms.
STATION VII.	Lat. N. 47° 36′.	Long. W. 7° 31′.	$\frac{\cdot}{444}$ fathoms.

This is a common species off the coast of Ireland (Stephens), in the Bay of Biscay (Roule), and in the Mediterranean Sea.

The Mediterranean species of Caryophyllia have been carefully studied by de Lacaze Duthiers, and on the diagnoses given by the distinguished French naturalist I have no difficulty in assigning all the specimens that I have examined to the species *C. clavus.* It is true that a few specimens appear to approach *C. Smithii,* which de Lacaze Duthiers regards as a distinct species and not a mere variety of *C. clavus.* The following measurements taken at random will express better than words the fact that the crown has the characteristic oval outline of *C. clavus* rather than the round outline of *C. Smithii*:—

Height . . .	26 mm.	21	18	16	13
Maximum diameter	22 mm.	19	19	18	14
Minimum diameter .	14·5 mm.	12	12	12·5	9

There is a complete series of specimens from the maximum size, the measurement of which is given in the first column to specimens less than 1 mm. in diameter. The collection would be of great value to any one willing to undertake a systematic study of the variations of the species.

The species was also obtained by the *Caudan,* and is common in deep and occasionally found in shallow water in the Mediterranean Sea (de Lacaze Duthiers).

Desmophyllum cristagalli, Milne Edwards and Haime.

Desmophyllum ingens, Moseley, *Challenger Reports,* vol. ii. 1881, p. 160.

STATION VII. Lat. N. 47° 36′. Long. W. 7° 31′. $\frac{\cdot}{444}$ fathoms.

There are four specimens of this species in the collection. The name *D. ingens* was given to some "gigantic" specimens obtained by the *Challenger* in 345 fathoms in the fiords of Patagonia. I am inclined to agree with Roule that these specimens cannot be separated from the older species *D. cristagalli.*

The following measurements may be of some interest:—

	Extreme length.	Greatest diameter of the calyx.	Shortest diameter of the calyx.
Largest *Challenger* specimen .	135	82	50
Largest *Huxley* specimen . .	100	37	25
Huxley specimens 2 and 3 .	75	33	25
Huxley specimen 4 . . .	55	22	17

OCULINIDÆ.

Lophohelia prolifera, Pall.

Amphihelia oculata, Linn.

Amphihelia ramea, Müller.

STATION VII. Lat. N. 47° 36′. Long. W. 7° 31′. $\frac{\cdot}{444}$ fathoms.

STATION XIII. Lat. 48° 7′ N. Long. 8° 13′ W. 412 fathoms.

There can be no doubt that the corals obtained by the *Huxley* at these stations are the same as those obtained by the *Porcupine* at 59° 56′ N., 6° 27′ W., 363 fathoms, and some other localities in the same part of the ocean. Duncan has given a description and several excellent figures of these corals (*Trans. Zool. Soc.*, viii. 1872, p. 330), and commented on their extreme variability. The difficulty of expressing in a diagnosis in words the difference between the species has not yet been overcome, and after carefully studying his work and that of Moseley (*Challenger Reports*, vol. ii. p. 178) and of de Lacaze Duthiers (*Arch. Zool. Expér.*, 3°, v. 1897), I have been unable to determine what should be, on scientific or historical grounds, the proper limits of the species. The difficulties the systematist finds in dealing with this group are: (1) the great range of variation that each species exhibits in the size of the calices, the manner of growth and ramification of the colonies, the size and even the presence of a columella, the size and the degree of exsertion of the septa, etc.; (2) the accommodation of the growth of the cœnenchym to the worm-tubes and other objects which the colonies encrust; (3) the amalgamation of the colonies of the different species.

(1) As regards the first difficulty, the calices of *Lophohelia* vary from 4 to 15 mm. in diameter across the rim of the calyx, of *Amphihelia oculata* from 3 to 5 mm., of *Amphihelia ramea* from 2 to 3 mm., the measurements of the larger zooids only of each colony examined being taken. The presence of a columella in *Amphihelia* cannot be relied upon as a trustworthy character to distinguish that genus from *Lophohelia*. On two branches of a colony I regarded as clearly belonging to *Amphihelia oculata* I found that some calices had a columella, others had not, and in others the columella was rudimentary.

(2) All three species exhibit a remarkable power of forming a growth of cœnenchym over worm-tubes or other objects with which they come into contact. This power ("La puissance blastogénétique" of de Lacaze Duthiers) by determining the character or shape of the support also determines to a great extent the general character of the facies of the colony, and as all three species appear to be partial to a tubular encrusting growth round the tube of the Polychæte worm

Eunice philocorallia, many of the colonies of the three species are very similar in their manner of growth. Many of the specimens in the collection exhibit these tubular growths of cœnenchym with the worm inside. (See F. Buchanan, *Proc. R.D.S.*, viii. (N.S.), 1893, p. 169, and Haddon, l.c., part iv. 1895.)

(3) If we are prepared to agree with the current views that the three species are really distinct, then we must suppose that very frequently a larva of one species becomes fixed to a colony of another, and the cœnenchym of the two colonies becomes fused or amalgamated. So intimate is this amalgamation of the cœnenchyms that it is impossible to tell by surface views or the examination of the ground surface of the coral where the cœnenchym belonging to the one colony begins and the other ends. This difficulty has been observed by de Lacaze Duthiers. He writes (l.c., p. 149): "Les deux espèces [*Lophohelia prolifera* and *Amphihelia oculata*] très souvent sont greffées l'une sur l'autre et se ressemblent extrêmement." And in attempting to distinguish between them he writes (p. 151): "J'avais pensé que peut-être la texture intime microscopique donnerait quelques indications. Après avoir fait des coupes minces bien polies, je n'ai pas trouvé de grandes différences entre la tige de l'*Amphihelia* et celle du *Lophohelia*."

The position of the problem appears to be as follows: All the authors who have examined the species agree that they are very variable, but no one has yet made a serious attempt to determine the range of variation in any one species. Until we know whether the species really merge and overlap, or do not, it is little better than a waste of time to attempt to determine the species by the ordinary methods of the systematist. To throw some light on the problem a systematic study should be made of the range of variation in one or more large colonies of the three "supposed" species. The collection obtained by the *Huxley* affords sufficient and excellent material for such an investigation, and it may be suggested that such an investigation might be undertaken.

The Hydroids collected by the "Huxley" from the North Side of the Bay of Biscay in August, 1906.

By

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With Plates I. and II. and one Figure in the Text.

INTRODUCTION.

The Hydroids collected on the northern edge of the Bay of Biscay during a five days' cruise in August, 1906, by Dr. E. J. Allen, were entrusted to me for examination. I thank my friend Dr. Allen for giving me the opportunity of working through the collection, which contained thirty-seven species, including two new species (*Bimeria arborea* and *Bimeria biscayana*) and several rare deep-sea forms.

Our knowledge of the area occupied by the British Hydroids has been increased by this cruise. All the species taken at six out of the eight stations have been previously recorded for the British area. It was only at the two stations over 400 fathoms that foreign species occurred. Bathymetrical distribution has also made an advance, as several species were taken at a depth considerably greater than that hitherto recorded for them.

I have followed Hincks's nomenclature very closely, because the names are so familiar to us, though I foresee that a day is not far distant when other generic names, which at present are only known to specialists, will have to be introduced into our faunistic lists.

The geographical distribution of nearly all the British species mentioned in this report has already been given by Dr. Allen in his paper on the "Fauna of the Eddystone Grounds," published in this journal in 1899, so that it is scarcely necessary to repeat the same records again. But since that date several important works on Hydroids have been published, and from these I have selected such records as are of geographical and bathymetrical importance.

LIST OF SPECIES, AND THE STATIONS AT WHICH THEY OCCURRED.

Station No.	I.	II.	III.	IV.	V.	VII.	IX.	XIII.
Latitude, N.	48° 25′	48° 24′	48° 24′	47° 48′	47° 48′	47° 36′	48° 7′	48° 7′
Longitude, W.	6° 28′	6° 28′	6° 33′	7° 25′	7° 46′	7° 31′	8° 13′	8° 13′
Fathoms	75	75	75	109	109	444	240	412
GYMNOBLASTEA.								
Bimeria nutans (Wright)	+	+	–	–	–	–	–	–
,, vestita, Wright	–	+	–	–	–	–	–	–
,, arborea, n. sp.	–	–	–	–	–	–	–	+
,, biscayana, n. sp.	–	–	–	–	–	–	–	+
Eudendrium ramosum (Linn.)	–	–	–	+	–	–	–	–
,, rameum (Pallas)	–	+	–	–	–	+	–	+
Tubularia sp.	–	+	–	–	–	–	–	–
CALYPTOBLASTEA.								
Clytia johnstoni (Alder)	+	+	–	–	–	–	–	–
Campanularia hincksii, Alder	+	+	–	–	+	+	+	+
,, raridentata, Alder	–	–	–	+	–	–	–	–
Calycella fastigiata (Alder)	+	–	–	+	–	–	+	–
Lafoëa dumosa (Fleming)	–	+	–	–	+	–	–	+
,, fruticosa (M. Sars)	+	+	–	–	–	–	–	–
,, pinnata, G. O. Sars	–	–	–	–	–	–	–	+
Filellum serpens (Hassall)	–	+	–	–	–	–	+	–
Perisiphonia pectinata, Pictet and Bedot	–	–	–	–	–	–	–	+
Cryptolaria humilis, Allman	–	–	–	–	–	–	–	+
Cuspidella grandis, Hincks	+	–	–	+	–	–	–	–
,, costata, Hincks	+	–	–	–	–	–	–	–
Halecium sessile, Norman	–	–	–	–	–	–	–	+
Sertularella polyzonias (Linn.)	+	+	+	+	+	–	+	–
,, gayi (Lamouroux)	–	–	–	–	–	+	–	+
Diphasia pinaster (Ellis and Solander)	+	+	–	+	+	–	–	–
,, tamarisca (Linn.)	+	+	–	–	–	–	–	–
,, pinnata (Pallas)	–	–	+	–	–	–	–	–
,, alata, Hincks	–	–	–	+	+	–	–	–
Sertularia abietina (Linn.)	–	+	+	–	–	–	+	–
Hydrallmania falcata (Linn.)	+	–	–	–	–	–	–	–
Plumularia elegantula, G. O. Sars	–	–	–	–	–	+	–	+
,, setacea (Ellis)	+	–	–	–	–	–	–	+
,, frutescens (Ellis and Solander)	–	–	–	–	–	–	–	+
Antennularia antennina (Linn.)	+	+	–	–	–	–	–	–
,, ramosa (Lamarck)	–	+	–	–	–	–	–	–
Antennopsis norvegica (G. O. Sars)	–	–	–	–	–	–	–	+
Aglaophenia myriophyllum (Linn.)	+	+	–	–	–	–	–	–

STATIONS AND THEIR CHARACTERISTIC HYDROIDS.

STATION I. East side of Parson's Bank. 75 fathoms.

At this station an ordinary dredge was dragged for about a mile over a sandy bottom. Here were found rooted in the sand *Aglaophenia myriophyllum* and *Antennularia antennina*, which may be regarded as the characteristic Hydroids of this ground. Attached to shells and worm-tubes (*Chætopterus*) were colonies of *Sertularella polyzonias*, *Diphasia pinaster*, and *Diphasia tamarisca*, and on a broken pecten shell was a nice compact colony of *Cuspidella grandis*. Eight other

species were found, nearly all of them being fixed to the larger Hydroids, *Aglaophenia*, *Antennularia*, and *Sertularella*.

Station II. This station is a continuation of Station I., but here an Agassiz trawl was used in the place of a dredge. There is a distinct decrease in the number of *Aglaophenia myriophyllum* and *Antennularia antennina*. The dredge, no doubt, is a better instrument for digging out these rooted Hydroids than the trawl. On the other hand, *Sertularella polyzonias* and *Diphasia pinaster*, both attached to worm-tubes, show an increase in number in the haul taken by the trawl over that of the dredge.

The species taken at this station are nearly the same as those found at the first station, but *Sertularia abietina* is an addition. The latter is a fine old colony with branches thickly covered with other small Hydroids.

Station III. A large otter trawl was used at this station, which was a few miles south-west of Station II. The trawl brought up a fine large colony of *Diphasia pinnata*, and a large colony of *Sertularia abietina*. Upon the latter were attached small colonies of *Sertularella polyzonias*.

The great falling off in the number of colonies at this station must be put down to the use of the otter trawl.

All the Hydroids taken at Stations I., II., and III. have been recorded for the Eddystone Grounds. There is a remarkable similarity between the Hydroid fauna of the two regions, though they are far apart.

Station IV. Near La Chapelle Bank. 109 fathoms. Bottom deposit—coarse sand and broken shells.

This station was about fifty miles to the south-west of Station III., and here a dredge was used. It brought up a large colony of *Sertularella polyzonias* attached to a worm-tube, a very fine colony of *Diphasia alata*, and a small colony of *Diphasia pinaster* on a worm-tube. Four other species were found upon these Hydroids.

Station V. 109 fathoms. Bottom deposit—coarse sand and shells.

An Agassiz trawl was used at this station, which was not far from Station IV.

Here *Diphasia alata*, *Sertularella polyzonias*, and *Diphasia pinaster* were again the principal Hydroids. *Diphasia alata* may be regarded as the characteristic Hydroid for Stations IV. and V. It was not taken at any of the other stations, and it has not been recorded for the Eddystone Grounds.

Station VII. Over 444 fathoms.

Although this station was only a few miles south of Station V., the water is about four times as deep. An Agassiz trawl was used, but it

brought up very few Hydroids. Here were found some large colonies of *Sertularella gayi*, to which are fixed a few colonies of *Campanularia hincksii*, a large branch of *Eudendrium rameum*, and fragments of *Plumularia elegantula*.

STATION IX. 240 fathoms. Bottom deposit—fine sand.

This station belongs to another area, about forty miles north-west of Station VII. Only a few Hydroids were taken, and all were broken into fragments. *Sertularia abietina* and *Sertularella polyzonias* appear to be the principal forms.

STATION XIII. 412 fathoms. Bottom deposit—sand, mud, and hard ground.

This station was not far from Station IX., but it was on the side of the Atlantic slope. For Hydroids it is certainly the most interesting of all the stations, as it was just beyond the range of the British Hydroid fauna. At all the other stations every Hydroid (except *Plumularia elegantula* at Station VII.) had been previously recorded within the British area, and described in Hincks's classical monograph.

At this station an Agassiz trawl was used, and it struck a large bed of the coral *Lophohelia prolifera*, to which many Hydroids were attached.

Amongst the larger Hydroids were *Eudendrium rameum, Halecium sessile, Sertularella gayi*, and two new species of *Bimeria* (*B. arborea, B. biscayana*). The foreign species include *Lafoëa pinnata, Perisiphonia pectinata, Cryptolaria humilis, Plumularia elegantula,* and *Antennopsis norvegica*. The occurrence of *Perisiphonia pectinata* and *Cryptolaria humilis* extends their geographical range further north.

Several species have their bathymetrical distribution considerably extended into deeper water, namely, *Eudendrium rameum, Campanularia hincksii, Halecium sessile, Plumularia elegantula, Plumularia setacea*, and *Plumularia frutescens*.

Two more foreign species were taken, which are not mentioned in this report. They look something like a *Cryptolaria*, but possess an operculum. If the colonies had been complete and in better condition I would have described them.

GYMNOBLASTEA.

BOUGAINVILLIDÆ.

Character of the family. Trophosome—hydranths with conical hypostome, tentacles filiform in a single verticil. Gonosome—gonophores, planoblasts, or hedrioblasts (Allman, 1888).

BIMERIA, Wright, 1859.

Generic character. Trophosome—hydrocaulus well developed, usually erect and branching; hydranths fusiform. Gonosome—gonophores in the form of sporosacs developed upon the hydrophyton.

The above description of the genus is almost identical with that given by Torrey (1902), who has emended Hincks's description and broadened it, so as to include the genus *Garveia*. According to Allman and Hincks, *Bimeria* is distinguished from *Garveia* by the perisarc, covering the lower part of the hydranth, extending over the proximal half of each tentacle, a character more suitable for a species than for a genus.

I am distinctly in favour of constituting the genus *Bimeria* in such a manner that it may stand in relation to *Bougainvillia* as *Coryne* does to *Syncoryne*, the trophosomes of the two genera being somewhat similar, but their gonosomes quite distinct, the former possessing sporosacs and the latter planoblasts.

It must be remembered that *Bimeria vestita* is the type species of the genus. Its trophosome in general appearance is very much like a *Bougainvillia*. Madame Motz-Kossowska (1905) has, however, transferred *Bimeria vestita* to the genus *Perigonimus*, which, like *Bougainvillia*, reproduces by means of planoblasts. The planoblasts of *Perigonimus* and *Bougainvillia* are not all alike, in fact they belong to two distinct medusoid families.

It would be an advantage to place *Pruvotella grisea*, Motz-Kossowska (1905), in the genus *Bimeria*. The generic character of *Pruvotella*, as given by Madame Motz-Kossowska, should make an excellent specific character.

I certainly prefer to place Hydroids, like *Bougainvillia*, with planoblasts, and Hydroids, like *Bimeria*, with sporosacs into separate genera, though there may be a few cases in which it is hard to draw the line. I notice that naturalists who have confined their attention solely to the trophosome completely disregard the nature of the gonosome in their classifications. They consider it is a matter of no importance whether the gonosome is a planoblast or a sporosac, and ignore the fact that medusæ have also a system of classification. I am strongly of the opinion that the gonosome should play an important part in the classification of Hydroids, especially in those Hydroids which liberate free-swimming medusæ.

Bimeria (Garveia) nutans (Wright).

This Hydroid occurred at Station I., 75 fathoms, on *Sertularella polyzonias*, and at Station II. it was common on *Sertularia abietina*. The colonies are without gonophores.

Bimeria nutans is generally found in the form of an erect arborescent colony, but here it was growing as a creeping form, without branches. The hydrocaulus has become a creeping stolon giving off at intervals single hydranths, which are on fairly long stalks.

A change in the mode of growth is not uncommon among Hydroids, and is one of the difficulties in connection with the drafting of precise generic characters. Arborescent colonies of *Syncoryne* and *Bougainvillia*, when so placed in small aquaria that a branch is in contact with the glass, will frequently send out a shoot which, on adhering to the glass, becomes converted into a stolon. The stolon develops single hydranths on long stalks, which seldom branch. The mode of growth of the new colony is distinctly that of a creeping form, whereas the old colony retains its arborescent growth.

Bimeria vestita, Wright.

At Station II., 75 fathoms, this species was fairly common on *Sertularia abietina*.

It can at once be recognised by having the lower half of each tentacle sheathed with a layer of perisarc. When the hydranths are in a contracted condition the sheath is scarcely visible, and then a colony looks like a little *Bougainvillia*.

Distribution. Firth of Forth (Wright, Allman); Yorkshire, Whitby (Hincks); Devonshire, Torbay and Salcombe (Hincks); Start Bay, 20–23 fathoms (E.T.B); Lancashire, Morecambe Bay (Allman); Irish Sea (Thornely); Ireland, Lough Swilly (Duerden); Heligoland (Hartlaub, 1897); Mediterranean, near Banyuls (Motz-Kossowska).

Bimeria arborea, nova species. Plate I., figs. 1–3. Plate II.

At Station XIII., 412 fathoms, was taken a large tree-like Hydroid, which at first sight looked like an aged colony of *Bougainvillia*, but since the gonophores were found to be true sporosacs, it showed the generic character of Bimeria.

Description of the species. Trophosome—hydrocaulus well branched, attaining a height of about $3\frac{1}{2}$ inches; branching irregular, with a tendency towards one plane; stems and branches fascicled; hydranths with about twelve tentacles in a single verticil; perisarc continued over the lower part of the hydranths in the form of a cup, into which the hydranth contracts. Gonosome—sporosacs situated on the hydrocaulus.

The specimens consist of a large colony (Plate II.) and several small pieces. It is quite probable that they all formed part of one colony, which the trawl had torn off above the root.

The stem and branches have a central axial tube surrounded by a large number of delicate auxiliary tubes. Apparently all the

hydranths and gonophores are directly connected with the axial tube, and the auxiliary tubes only give rigidity to the stem and branches. The auxiliary tubes greatly increase the thickness of the stem and the principal branches, and extend, in decreasing numbers, almost to the extremities of the little branches, but do not run along the stalks of the hydranths.

The hydranths (Pl. I., Fig. 1) have rather a broad, cone-shaped hypostome surrounded by a single row of about twelve tentacles, but occasionally thirteen are present. It is not possible to say definitely that the tentacles during life naturally arrange themselves in two alternating series, one elevated and the other depressed, as in *Bougainvillia*. A few of the hydranths certainly show such an arrangement, but as nearly all the hydranths are in a contracted or semi-contracted condition, the tentacles are also contracted. Surrounding the lower part of the hydranth is a cup-like expansion of the perisarc, into which the hydranth withdraws on contraction. This cup is conspicuous owing to its being covered with very fine black or dark brown particles. A similar coating occurs in *Bimeria vestita* and *Bougainvillia*. The stalks of the hydranths are smooth, except at their origin, where there are a few slight wrinkles or corrugations. The axial tube is also smooth, but it is only exposed just at the tips of the branches.

The gonophores (Fig. 3) are situated upon the branches, and not upon the hydranths or their stalks. The male gonophore is globular in shape, and is upon a short pedicel. Sections (Fig. 2) show that it is a true sporosac. At the base of the spadix slight outgrowths of the endoderm indicate rudimentary radial canals, such as are found in the gonophore of *Garveia nutans*.

Bimeria biscayana, nova species. Plate I., figs. 4, 5.

At Station XIII., 412 fathoms, six colonies of a small Hydroid, about 20 mm. or less in height, were found attached to the coral *Lophohelia*. As the colonies have compound branches of considerable thickness for the size of the colonies, and are without gonosomes, they are probably at an early stage in their growth, and may reasonably be expected to grow to a much larger size.

Description of the species. Hydrocaulus compound, composed of series of tubes bearing individual hydranths. Some of the stems of the hydranths become branches. Hydranths with about ten tentacles in a single verticil. Perisarc continued over the lower part of the hydranth in the form of a small cup, into which the hydranth contracts. Gonosome unknown.

Theoretically, the main stem of the colony should be a single unbranched tube carrying a hydranth at its top. The hydranth

manufactures the tube and also secretes inside it thin layers of perisarc, which form a kind of coarse network (Fig. 4). Then from the root arise auxiliary tubes (stolons), which creep up the stem. From the auxiliary tubes bud forth numerous hydranths. At first the hydranths are sessile, and later on some develop a stalk; some are more vigorous than others and develop a long stalk, which becomes a branch, and is similar in structure to the original stem. Along the branches there creep from the root more auxiliary tubes bearing

Fig. 1.
Bimeria biscayana, n. sp. × 4.

hydranths. This process is repeated again and again, and results in the formation of an arborescent colony (Text Fig. 1).

The auxiliary tubes frequently anastomose with one another, and form a dense matted mass, which gives a considerable thickness to the principal branches.

The cœnosarcal tube of a hydranth, which forms a branch, apparently has no direct communication with the auxiliary tubes growing over the external surface of its perisarc. It is, however, in communication with other hydranths by means of its own auxiliary tube, from which it originally developed. The tube formed by the hydranth even when

it lengthens into a branch does not produce lateral branches. Wherever I could trace the course of the internal cœnosarcal tube it always came from an auxiliary tube.

The auxiliary tubes are simply stolons arising from the root of the colony, growing over one another, and producing series of single hydranths, the stems of which do not develop hydranths or branch.

As all the hydranths are more or less contracted, their natural shape remains uncertain. They possess a broad conical hypostome, and generally ten tentacles, but occasionally eleven are present. The stalk of the hydranth is smooth, of about the same thickness throughout its whole length, and terminates in a slight extension to form the cup for the hydranth. The hydranths which remain sessile or nearly so upon the auxiliary tubes gradually become surrounded by tubes of a later growth, and embedded to such an extent that only their heads are visible.

Until the gonosome has been found, this species can only be provisionally regarded as a member of the genus *Bimeria*. As the Hydroid was found at a depth of over 400 fathoms, its gonophore is almost certain to be a sporosac.

EUDENDRIDÆ.

Eudendrium ramosum (Linn.).

At Station IV., 109 fathoms, a few colonies were taken. They are very small in size and attached to worm-tubes.

Distribution. Some recent foreign records:—California (Torrey). Antarctic Ocean, lat. 71° S., long. 89° W.; lat. 71° S., long. 87° W.; lat. 70° S., long. 80° W.; 220 to 300 fathoms. (Species marked (?), Hartlaub, *Belgica* Expedition, 1904.)

Eudendrium rameum (Pallas).

At Station II., 75 fathoms, a small colony about 1 inch in height was taken. At Station VII., over 444 fathoms, the trawl brought up a piece which had evidently, from the thickness of the stem, been broken off from a large colony. At Station XIII., 412 fathoms, several small colonies were taken, and also a branch about 3½ inches in height. Some of the colonies have gonophores.

Distribution. Some recent foreign records:—Arctic Ocean, off Bear Island, lat. 74° 53′, long. 15° 55′ E., 180 fathoms (Bonnevie). S.E. of Iceland, lat. 62° 59′, long. 10° 37′ W., 250 fathoms (Broch, 1903). Portugal (Nobre). Off West Coast of Morocco, 33° 16′ N., 8° 53′ W., 65 fathoms (Billard). California (Torrey). Chile, about lat. 42° S. (Hartlaub, 1905). South Georgia, 135 fathoms (Jäderholm).

TUBULARIDÆ.

Tubularia sp.

At Station II., 75 fathoms, a single *Tubularia* Hydroid was found attached to a worm-tube. It has the appearance of a young form.

CALYPTOBLASTEA.

CAMPANULARIDÆ.

Clytia johnstoni (Alder).

A few colonies with gonophores were found at Stations I. and II., 75 fathoms. They were attached to *Sertularia abietina* and to other large Hydroids.

The bathymetrical distribution of *Clytia johnstoni* is from the shore down to about 100 fathoms.

Campanularia hincksii, Alder.

This species was fairly common at most of the stations, extending from 75 fathoms down to over 444 fathoms. It was usually attached to *Sertularella*, occasionally on *Antennularia*, but only once seen on a *Diphasia*. Colonies with gonophores were taken at Station II.

Campanularia hincksii is similar to *Clytia johnstoni* in its mode of growth and habitat, but differs in its method of reproduction. The gonophores contain fixed sporosacs which mature their products within the gonangium. *Clytia* liberates free-swimming medusæ which belong to the medusoid genus *Phialidium*.

It does not occur so close to shore as *Clytia*, but extends to a much greater depth.

Distribution. Some recent foreign records :—Off east coast of Greenland, 74° 7′ N., 19° 4′ E.; 50 fathoms; 0·19° C. Off Norwegian coast, 62° 17′ N., 4° 57′ W.; 145 fathoms (Broch, 1903). Morocco, off Cape Spartel, 60 fathoms (Billard).

Campanularia raridentata, Alder.

A few hydranths resembling Alder's figure were seen on *Sertularella*, and on a broken shell at Station IV.

CAMPANULINIDÆ.

Calycella fastigiata (Alder).

A few colonies were found attached to *Sertularella* and to the roots of *Diphasia alata*, 75–240 fathoms.

Distribution. Some foreign records:—Norway, Aelesund, 55–100 fathoms (Bonnevie). Gulf of Gascogne, 225 fathoms. Off west coast of Morocco, 33° 16′ N., 8° 53′ W.; 60 fathoms (Billard).

LAFOËIDÆ.

Lafoëa dumosa (Fleming).

The erect form (var. *robusta*) was common at Station II., but scarce at Station V. The creeping form also occurred at Station II., and on *Lophohelia* at Station XIII., 412 fathoms.

The deepest record for this species is 450 fathoms, off Sombrero Island, West Indies (*Challenger* Expedition).

Lafoëa fruticosa (M. Sars), var. *gracillima*, Alder.

This species was very scarce; just a few colonies from Stations I. and II., 75 fathoms. At the second station it was growing over worm-tubes.

There appears to be a difference of opinion as to whether *Lafoëa gracillima*, Alder, and *Lafoëa fruticosa*, Sars, are the same species or distinct species. *Lafoëa gracillima* has its hydrotheca on a stalk which has one or two very loose twists, but *Lafoëa fruticosa* has three or four distinct spiral twists. The specimens in this collection belong to Alder's type, which is the type found in the English Channel, and which has usually been called *Lafoëa fruticosa*.

Distribution. Jäderholm has recently recorded *Lafoëa gracillima* for Falkland Islands and South Georgia.

One of the deepest records for *Lafoëa gracillima* is 274 fathoms, off the Norwegian coast, 62° 30′ N., 1° 56′ E. (Broch, 1903).

Lafoëa pinnata, G. O. Sars.

Lafoëa pinnata, G. O. Sars, 1873, p. 116, Tab. IV. figs. 25–28; Bonnevie, 1899, p. 69, Pl. VI. fig. 1.

Lafoëa halecioides, Allman, 1874, p. 472, Pl. LXVI. fig. 1.

Lictorella halecioides, Pictet et Bedot, 1900, p. 16, Pl. III. figs. 4, 5.

Lictorella pinnata, Broch, 1903; Broch, 1905, p. 11, fig. 3.

This species was taken at Station XIII., 412 fathoms, and was either growing over *Eudendrium rameum*, or fixed to the coral *Lophohelia*.

It was first described by G. O. Sars, who found it on *Eudendrium rameum* in the Hardangerfjord, on the coast of Norway. In 1874 Allman described a new species of *Lafoëa* under the name of *Lafoëa halecioides*, which was found by the *Porcupine* Expedition in the Faeroe Channel, and this appears to me to be identical with *Lafoëa pinnata*.

Allman (1888), in the Report on the Hydroida of the *Challenger* Expedition, considered a Hydroid from Torres Straits, North Australia, to be identical with *Lafoëa halecioides* from the Faeroe Channel, and on account of the structure of the hydrotheca of the Australian specimen, he transferred *Lafoëa halecioides* to a new genus called *Lictorella*.

Through the kindness of Mr. R. Kirkpatrick, I have examined at the British Museum the specimen of *Lictorella halecioides* from Torres Straits. It is not like *Lafoëa pinnata*, and it is not like Allman's figure of *Lafoëa halecioides* from the Faeroe Channel.

Pictet and Bedot record the occurrence of *Lictorella halecioides* in the Bay of Biscay. Their description and beautiful figures show that they refer to the form originally described by Allman from the Faeroe Channel.

The distinction between the two genera *Lafoëa* and *Lictorella* rests entirely upon the structure of their hydrothecæ. In *Lafoëa* the cavity of the hydrotheca is directly continuous with that of the stem or peduncle, but in *Lictorella* the cavity is distinctly differentiated from that of the peduncle.

In the lower part of the hydrotheca of *Lafoëa pinnata* there is a fine transverse circular line on the inner side of the perisarc. The line is more readily seen when the hydrothecæ are empty, and, better still, when the perisarc has been lightly stained. Two circular lines, close together, are not uncommon, and occasionally a hydrotheca was seen without a circular line. In mounted specimens one usually sees this line and nothing more, but occasionally in an empty hydrotheca a very fine membrane, with a central hole, was found stretching across the hydrotheca. The circular line is a very slight thickening of the perisarc, to which this membrane is attached. When the colony is alive the membrane extends from the body of the hydranth to the perisarc of the hydrotheca, and shuts off the lower part of the hydrotheca from the exterior. The membrane is so thin and delicate that it usually disappears on the death or absorption of the hydranth. Levinsen (1893) has noticed a similar membrane in *Lafoëa fruticosa*. This membrane has commonly been called a diaphragm and considered homologous with the diaphragm of a typical Campanularian Hydroid. To compare this delicate membrane with the firm perisarcal diaphragm which forms the bottom of the hydrotheca of a Campanularia is likely to cause confusion. The membrane is not at the bottom of the hydrotheca, and it does not, on account of its pliability, in any way limit the contracting back of the hydranth; when the hydranth of a *Lafoëa* is contracted back it does not rest upon the diaphragm like a *Campanularia*, but contracts back below the diaphragm to the bottom of the hydrotheca.

Lictorella halecioides from Torres Straits has a typical Campanularian diaphragm. Its hydrotheca, with a thick basal wall, is upon a short peduncle, and the cavity of the hydrotheca is distinctly differentiated from that of the peduncle.

Description of *Lafoëa pinnata*. This Hydroid has two modes of

growth: (*a*) A creeping form which occurs on *Eudendrium*. In this form the stolon either gives off stems bearing only hydranths, or stems with lateral branches which carry the hydranths. The stem is either simple, monosiphonic, or fascicled. A fascicular stem has usually only one or two auxiliary tubes. (*b*) An erect form which is distinguishable from the creeping form by the main stem being thick and composed of many auxiliary tubes, and by the presence of thick fascicular branches which give off branchlets to bear the hydranths.

Sars has described and figured the creeping form on *Eudendrium*. Allman, Bonnevie, and Bedot, figure the erect form, which reaches a height of 70 mm. In this collection both forms occur; the erect form is similar to the figures given by Allman and Bedot.

The peduncle of the hydrotheca has the appearance of being twisted near its base. There is not a distinct joint, but rather a corrugation of the perisarc. Occasionally a peduncle was seen without the slightest trace of even a wrinkle, but peduncles with several transverse corrugations or even with two or three distinct rings were more frequently seen.

The hydrothecæ are alternately situated upon the stem, and all turn towards the same side of the colony. They frequently show several rings of growth near their orifice. A single hydrotheca is also present in the axil of the branches.

In addition to the ordinary hydrothecæ, there are very minute pedunculated cups, resembling somewhat in shape and size the sarcothecæ of *Perisiphonia pectinata* (Pictet and Bedot, 1900, Pl. IV. figs. 2*b*, 2*c*). They occur either at the axil of a branch, or at the base of the peduncle of a hydrotheca, or on an auxiliary tube of the stem. They are, however, extremely scarce; one branch may have two or three, and another none at all. Some have, undoubtedly, been broken off, as minute holes were found in the perisarc in the places where they should occur, but even the holes are very scarce. A few of the sarcothecæ contain a little cœnosarc which is usually in a contracted or dilapidated condition.

The existence of nematophores in *Lafoëa pinnata* has not been previously noticed, but before changing the generic name again it would be well to know if similar nematophores occur in specimens from other localities, especially off the Norwegian coast. If so, then I would suggest that the species be transferred to the genus *Zygophylax*, Quelch. There seems to be a close relationship between my specimens of *Lafoëa pinnata* and *Zygophylax biarmata* (Billard, 1907).

All the colonies are without gonosomes. Bonnevie has figured the gonosome, and it belongs to the *Scapus* type.

Distribution. Arctic Ocean, 71° 45′ N., 15° 41′ E., 620 fathoms

(1134 metres), 0·97° C.; 72° 27′ N., 35° 1′ E., 136 fathoms (249 metres), 0° C. (Bonnevie). Norway, Hardangerfjord, 90–100 fathoms (Sars). Between Iceland and Greenland, 66° 42′ N., 26° 40′ W., 320 fathoms, +0·11° C. (Broch, 1903). Faeroe Channel, 61° 10′ N., 2° 21′ W., 345 fathoms, 30° F.; 61° 21′ N., 3° 44′ W., 640 fathoms, 30° F. (Allman, 1874). Off north-west of Scotland, 59° 28′ N., 8° 1′ W., 600–700 fathoms (1100–1300 metres) (Broch, 1903). North-west of Faeroe Islands (Broch, 1903). Bay of Biscay, off north coast of Spain, 43° 4′ N., 8° 55′ W., 80 fathoms (Pictet and Bedot).

Filellum serpens (Hassall).

Lafoëa serpens, Bonnevie, 1899.

This species was very common on *Sertularella abietina* at Stations II. and IX., 75–240 fathoms.

Both Levinsen and Bonnevie state that the gonosome belongs to the *Coppinia* type, and a figure of it is given by Bonnevie.

Filellum serpens has recently been recorded by Jäderholm from the Falkland Islands and Tierra del Fuego. It was found by the Norwegian North Atlantic Expedition at many different stations, 10–328 fathoms (Bonnevie).

Perisiphonia pectinata, Pictet et Bedot.

Perisiphonia pectinata, Pictet et Bedot, 1900, p. 18, Pl. IV. V.

There is only one specimen of this interesting Hydroid, which was taken at Station XIII., 412 fathoms, and found attached to the coral *Lophohelia*. The main stem is about 20 mm. in height, and has twelve alternating branches.

There are some exceedingly beautiful figures of this species drawn by Bedot, who believes that his specimens, taken in the Gulf of Gascogne and at the Azores, are identical with those described by Allman (1888) under the name of *Perisiphonia pectinata*. Allman has described two species of *Perisiphonia*—*P. filicula* from the Azores and Australia, and *P. pectinata* from off the coast of New Zealand. My specimen agrees very well with Bedot's figures, but I am not sure that it is identical with either of Allman's species.

The stem and branches have a principal axial tube from which the hydrothecæ arise, and it is surrounded by a number of auxiliary tubes, which do not bear hydrothecæ, but numerous minute sarcothecæ. The presence of sarcothecæ is the characteristic feature of the genus.

The hydrothecæ are adnate for about half their length to the axial tube. According to Allman, a pedunculated hydrotheca is one of the characters of the genus, but I think that this detail might be omitted from the generic characters and passed down to the species. At the

base of the hydrotheca there is a transverse ring, which indicates the presence of a diaphragm similar to the one mentioned in *Lafoëa pinnata.* The hydrothecæ have not the shape or position of those figured by Allman, but are similar to those figured by Bedot. Many of the hydrothecæ show circular rings of growth near their orifice.

The shapes of the sarcothecæ are similar to those figured by Bedot, but they are not like the long sarcothecæ on the auxiliary tubes of Allman's species. So far as I know, no one has yet examined a living *Perisiphonia*, so that the structure and form of the supposed sarcostyles are unknown.

Bedot fortunately found a specimen bearing a gonosome, which was previously unknown. It belongs to the *Coppinia* type, and a beautiful figure is given of it.

Cryptolaria humilis, Allman.

Cryptolaria humilis, Allman, 1888, p. 39, Pl. XVIII. fig. 1.

The collection contains only a fragment from the upper part of a colony. It was taken at Station XIII., 412 fathoms. The hydrothecæ are similar to those of *Cryptolaria humilis* as figured by Allman, and they are also like the hydrothecæ of *C. conferta*, Allman, and *C. crassicaulis*, Allman. It would be well to have these three species united, and a few more with them.

Distribution. *C. humilis:* off the Azores, 38° 30′ N., 31° 14′ W., 1000 fathoms (Allman, 1888). *C. conferta:* off Cuba, 450 fathoms (Allman, 1877); off the Azores, 70–250 fathoms (Pictet et Bedot); Gulf of Gascogne, 225 fathoms; off West Coast of Morocco and Soudan, Cape Spartel to Cape Garnet, 225–400 fathoms (Billard). *C. crassicornis:* off Ascension Island, 420 fathoms (Allman, 1888).

Cuspidella grandis, Hincks.

This species occurred at Station I., 75 fathoms, on *Sertularella polyzonias.* At Station IV., 109 fathoms, it was fairly common on *Sertularella* and *Diphasia alata.*

Cuspidella costata, Hincks.

This species was only taken at Station I., 75 fathoms, and was rather scarce.

HALECIDÆ.

Halecium sessile, Norman.

A single specimen was taken at Station XIII., 412 fathoms. It is about $2\frac{1}{2}$ inches in height, and has evidently lost some of its branches. The main stem is thick and fascicled; the principal branches are also fascicled and irregular in position.

The hydrothecæ are sessile, and around their orifice there are a number of fine lines. These lines look like a striated band, but on being subjected to a higher magnification each line is seen to be a projecting rim and to represent a rudimentary hydrotheca.

The gonangia (male) are very long and slightly curved. They are situated on the side of the hydrothecæ, either singly or in pairs. Their distal end is rounded, and the proximal end tapers towards a joint which is closed to the hydrotheca. The male gonangium agrees with Bonnevie's description. The female form is still unknown.

Distribution. Scotland, The Minch, in deep water (Hincks, 1868). Norway, Bodo, Lofoden, 55–100 fathoms (Bonnevie).

SERTULARIDÆ.

Sertularella polyzonias (Linn.).

This species occurred at all the stations, except at the two over 400 fathoms. It was usually attached to worm-tubes, shells, and occasionally to small stones or to another Hydroid. A few of the colonies taken at Station II. bear gonophores.

Jäderholm has recently recorded this species for the Falkland Islands and South Georgia.

According to Nutting, the greatest depth recorded for this species is 353 fathoms in the North Atlantic, off Florida.

Sertularella gayi (Lamouroux).

Large colonies, some of which are loaded with gonophores and carry their ova in acrocysts, were taken at Station VII., over 444 fathoms. The species was also fairly common at Station XIII., 412 fathoms.

Some of the colonies have very thick stems, and are evidently of a great age. Even quite small colonies have thick stems and branches, and have the appearance of old colonies producing a new growth of shoots.

Both *Sertularella polyzonias* and *S. gayi* are common species on the Eddystone Grounds, 30–35 fathoms, yet on this cruise *S. gayi* was only taken at the two stations over 400 fathoms, and there *S. polyzonias* was absent.

Sertularella gayi has been taken in the Faeroe Channel at the depth of 605 fathoms (Allman, 1874).

Diphasia pinaster (Ellis and Solander).

A few colonies, without gonangia, were taken at Stations I., II., IV., and V., 75–109 fathoms. Some were attached to worm-tubes.

Distribution. Hebrides, 40 fathoms; off Mull of Galloway, 110–140 fathoms; Dogger Bank; Jersey; Dublin Bay; and other places

(Hincks, 1868). South of the Eddystone (Bourne). Norway, 200 fathoms (Broch, 1903). Portugal (Nobre). Gulf of Gascogne, 100 fathoms; Azores, 75 fathoms (Pictet and Bedot). Off the Azores, 450 fathoms (Allman, 1888). Morocco, Cape Spartel, 60 fathoms; Cape Verde Islands, 220–320 fathoms (Billard).

Diphasia tamarisca (Linn.).

At Stations I. and II., 75 fathoms, a few small colonies and fragments were taken. Some of the colonies have gonophores.

Bonnevie records this species along the Norwegian coast from Kristiandsund to Hammerfest, and off the north-west coast of Norway in lat. 69° 44′, long. 16° 15′ E., 650 fathoms, 0·66° C.; and 71° 45′ N., 15° 41′ E., 622 fathoms, 0·97° C.

Diphasia pinnata (Pallas).

A splendid colony was taken at Station III., 75 fathoms. There are over a dozen shoots, the largest about 6 inches in height, and several are loaded with female gonophores.

The colony when alive was of a deep carmine colour, which slowly dissolved out in alcohol, and after its complete removal the colony became a dark brownish colour.

Distribution. South coast of Devon and Cornwall, about 30–40 fathoms (Hincks). As this species was not taken by the *Challenger* Expedition, and is not mentioned in recent foreign records, its occurrence outside the areas mentioned above is very doubtful.

Diphasia alata (Hincks).

At Station IV., 109 fathoms, a large colony, with many shoots and branches, up to 5 inches in height, and a small colony were taken. Both colonies were attached to worm-tubes. At Station V. several large branches were again taken.

The main stem is strengthened by a number of auxiliary tubes, which run along one side of it, and decrease in number towards the distal ends.

Several of the large shoots bear female gonosomes. The gonangia are similar to those of the male.

Distribution. Norway, Stavanger, 50–100 fathoms (Bonnevie). Shetlands, 40 fathoms (Hincks). Cornish coast (Hincks). Ireland, west coast, 43 fathoms (Duerden). Bay of Biscay, Gulf of Gascogne, 75–164 fathoms; Azores, 75–174 fathoms (Pictet and Bedot). Gulf of Gascogne, 225 fathoms (Billard).

Sertularia abietina (Linn.).

Abietinaria abietina, Nutting, 1904.

A fine old colony, closely covered with other small Hydroids,

was taken at Station II., 75 fathoms, and some large branches at Station III. At Station IX., 240 fathoms, a few fragments were secured.

Broch (1903) records this species at 250 fathoms in lat. 62° 59′ N., long. 10° 37′ W.

Hydrallmania falcata (Linn.).

A few fragments were obtained at Station I., 75 fathoms.

PLUMULARIDÆ.

Plumularia elegantula, G. O. Sars.

Plumularia elegantula, G. O. Sars, 1873, p. 103, Tab. III. figs. 9–14; Bonnevie, 1898, p. 15; Bonnevie, 1899, p. 90.

This species occurred at Station VII., over 444 fathoms, and at Station XIII., 412 fathoms. At the first station only two plumes were taken. The largest measures 35 mm. in length, and has a few empty gonangia on the stem. At the second station several young colonies were found attached to the coral *Lophohelia*.

It is very likely that this species is a deep-water variety of *Plumularia pinnata*. It agrees with the latter species in every detail, except that the internodes of the hydrocladia are nearly twice as long. The hydrothecæ are smaller in size, and are situated at the distal end of the internodes. Their position is probably due to the lengthening of the internode at its proximal end. It is the length of the internodes that gives the hydrocladia a more delicate and more slender appearance than that seen in the littoral *Plumularia pinnata*.

Distribution. Norway, Kristiania to Bodo, 55–200 fathoms (Bonnevie, 1899).

Plumularia setacea (Ellis).

At Station I., 75 fathoms, very small colonies bearing gonangia were found on *Aglaophenia* and *Antennularia*.

At Station XIII., 412 fathoms, several little colonies with gonangia were attached to *Plumularia frutescens*.

Distribution. Some recent foreign records :—Norway, 55–110 fathoms (Bonnevie); Azores, 174 fathoms (Pictet et Bedot); Florida (Nutting); California (Nutting); Puget Sound (Torrey); Chile (Hartlaub); Ceylon (Thornely); New Zealand (Hartlaub, 1901); Japan (Jäderholm, 1896).

Plumularia frutescens (Ellis and Solander).

A few short branches bearing gonophores were taken at Station XIII., 412 fathoms.

Bonnevie records this species for the coast of Norway, 20–160 fathoms.

Antennularia antennina (Linn.).

Small colonies were fairly common at Station I., 75 fathoms, but scarce at Station II.

Distribution. Recent foreign records:—Norway, 100–200 fathoms (Bonnevie); Bay of Biscay, Gulf of Gascogne, 10–35 fathoms (Pictet et Bedot); Portugal (Nobre); North Atlantic, off the American coast, lat. 42° N., long. 65° W., 65 fathoms; lat. 35° N., long. 75° W., 71 fathoms (Nutting).

Antennularia ramosa (Lamarck).

A few fragments were taken at Station II., 75 fathoms.

Distribution. Recent foreign records:—Bay of Biscay, Gulf of Gascogne, 35–75 fathoms (Pictet et Bedot); Portugal (Nobre); Azores, 75 fathoms (Pictet et Bedot).

Antennopsis, Allman, 1877.

Generic character (Nutting, 1900). Trophosome—stem jointed; cœnosarc not canaliculated; hydrocladia scattered irregularly over the stem, sometimes approaching a verticillate arrangement. Gonosome—gonangia borne in the axils of the hydrocladia, without protective appendages.

Antennopsis norvegica (G. O. Sars).

Heteropyxis norvegica, G. O. Sars, 1873, p. 104, Tab. III. figs. 15–22.

Antennularia norvegica, Bonnevie, 1899, p. 97.

Antennularia norvegica, Broch, 1903; Broch, 1905, p. 24; Billard, 1907, p. 217.

At Station XIII., 412 fathoms, a few colonies about 15–35 mm. in height were found upon *Lophohelia*.

In young colonies the arrangement of the hydrocladia on the stem is pinnate, as in the genus *Plumularia*. The same arrangement is found at the bottom of the larger plumes, but as the stem grows in length the hydrocladia no longer remain in the same plane. They project out in pairs, either alternate or opposite, at an angle of about forty-five degrees. At the distal end of the plume the hydrocladia become closer together and more irregular in position, and scattered in all directions round the stem. This irregular arrangement of the hydrocladia led Bonnevie to place the species in the genus *Antennularia*.

Nutting in his revision of the Plumularidæ has restricted the genus *Antennularia* to species with a canaliculated stem, and retains the genus *Antennopsis* for species with a simple or fascicled stem.

The specimens from the Bay of Biscay have a simple, monosiphonic stem. Bonnevie, however, states that the main is compound, which I interpret to mean a fascicled stem.

The internodes of the main stem are very irregular in length; some are quite long, carrying about eight hydrocladia, others are very short, with only two or three hydrocladia.

The nematophores are bithalamic and rather small. On each internode of the hydrocladia there are three, two situated in front of the hydrotheca and one behind it. There are also two in the axil of the hydrocladia, and several scattered over each internode of the main stem.

The gonangia are in the axil of the hydrocladia, usually one or two, but occasionally three are present. They are curved downwards, and contain a single ovum.

Distribution. Norway, Kristianfjord, 50–60 fathoms; Hardangerfjord, 90–100 fathoms (Sars). North Atlantic, off the Norwegian coast, 61° 41′ N., 3° 19′ E., 219 fathoms, +6° C.; 62° 44′ N., 1° 48′ E., 411 fathoms, −1·6° C.; 64° 48′ N., 6° 36′ E., 155 fathoms, +6·9° C. (Bonnevie). North Sea, 57° 11′ N., 1° 50′ W., 55 fathoms, 58° 0′ N., 3° 24′ E., 50 fathoms; 57° 9′ N., 1° 30′ E., 50 fathoms, +6·15° C. (Broch, 1905); 62° 16′ N., 6° 6′ W., 60 fathoms (Broch, 1903). South-west of Toulon, 245 fathoms (Billard).

Aglaophenia myriophyllum (Linn.).

Lytocarpus myriophyllum, Allman, 1883.

Thecocarpus myriophyllum, Nutting, 1900.

About thirty specimens were taken at Station I., 75 fathoms, and a few at Station II.

Distribution. Recent foreign records:—Off the coast of Norway, 200–400 fathoms (Bonnevie). Bay of Biscay, 50–135 fathoms; Azores, 70 fathoms (Pictet et Bedot). Portugal (Nobre). South of Madeira, 55 fathoms; off the west coast of Morocco, 300 fathoms; Cape Verde Islands, 220–320 fathoms (Billard).

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EXPLANATION OF PLATE I.

Figs. 1–3. *Bimeria arborea*, nova species, p. 20.

Fig. 1. The hydranth. × 100.

Fig. 2. Portion of a branch. × 9. G., Gonophore.

Fig. 3. The male gonophore. Longitudinal section. × 150.

Ec., Ectoderm. En., Endoderm. G., Gonads. R., Rudimentary radial canals. P., Perisarc.

Figs. 4–5. *Bimeria biscayana*, nova species. p. 20.

Fig. 4. Transverse section of the stem of a hydranth. × 180.

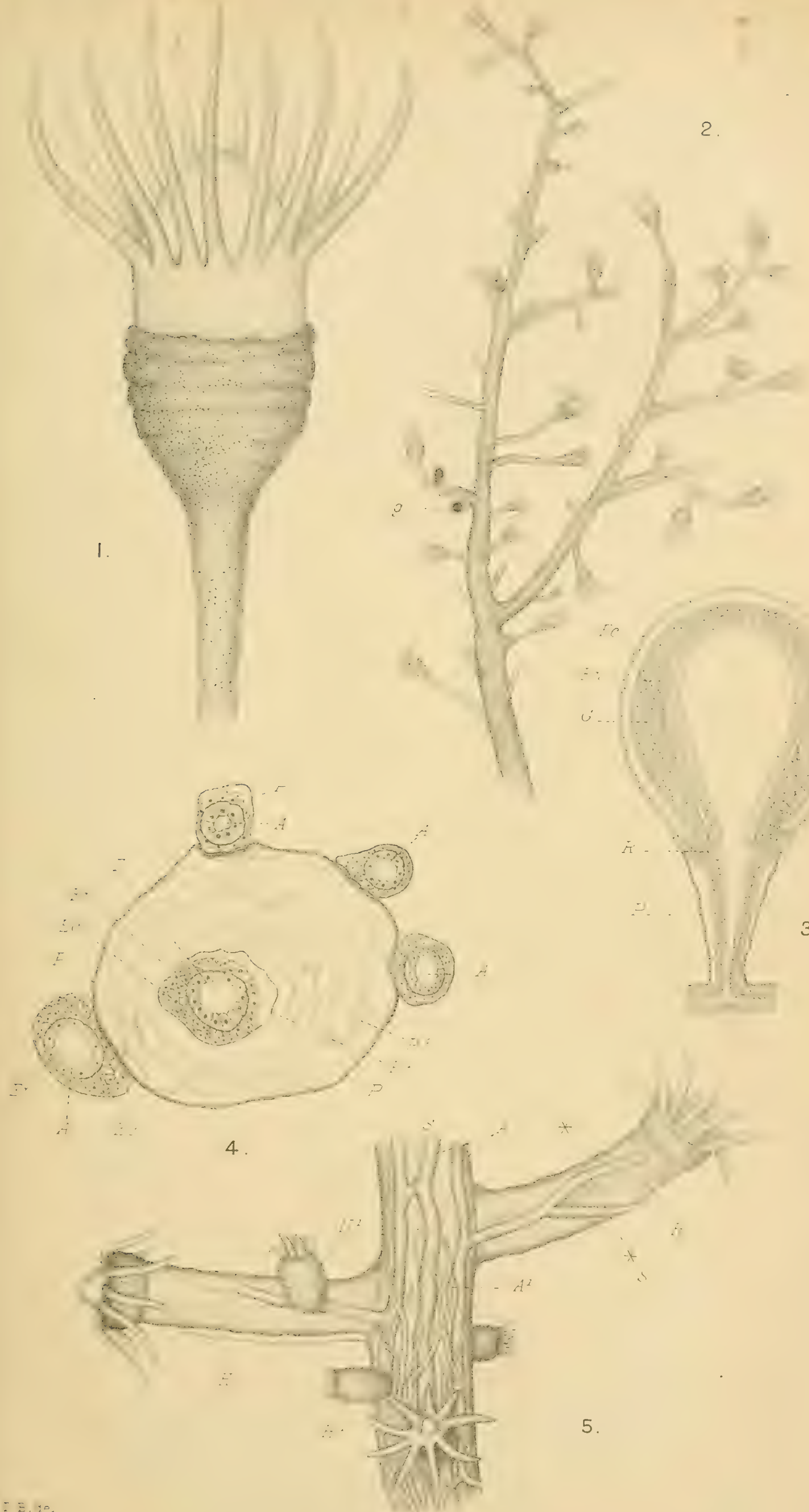
A., Auxiliary tubes. Ec., Ectoderm. En., Endoderm. P., Perisarc. P^1, Inner layer of perisarc. P^2, Intermediate layers of perisarc forming a coarse mesh-work.

Fig. 5. Portion of a branch drawn to show the arrangement of the hydranths and the auxiliary tubes. × 40.

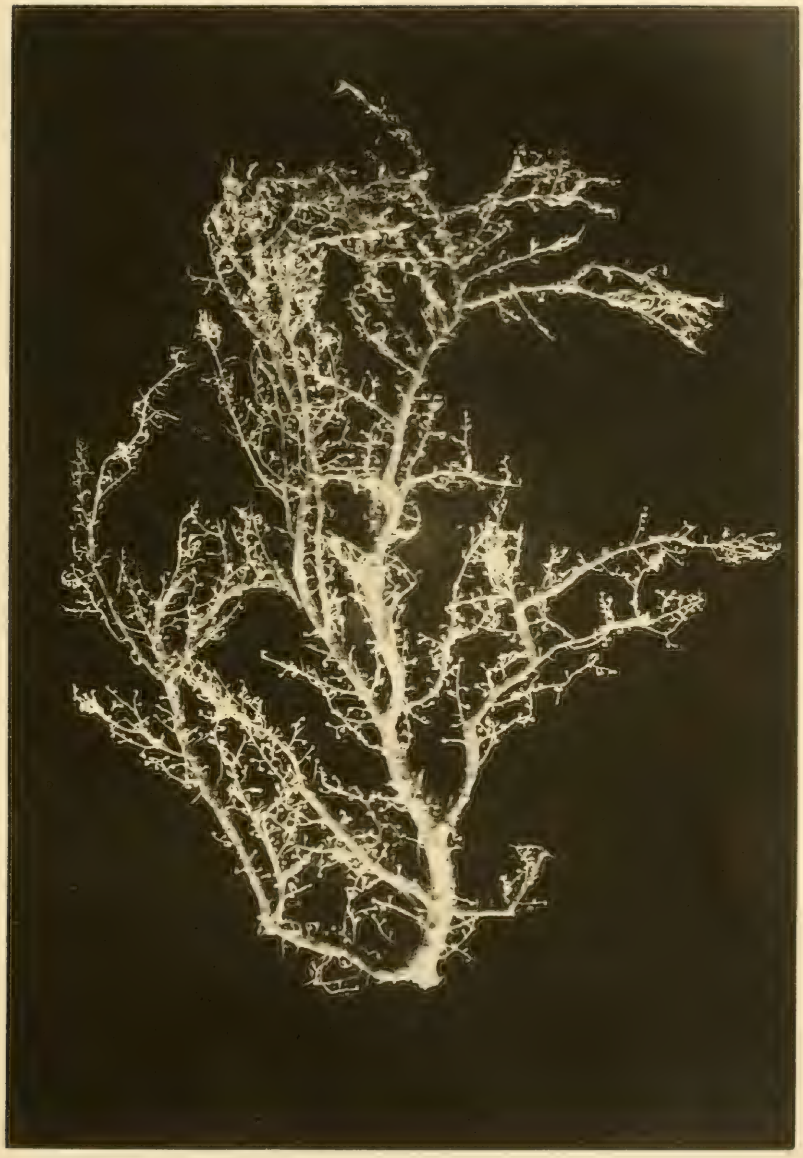
S., Stem of a hydranth which has grown into a branch. A., Auxiliary tubes growing over the branch and bearing hydranths H^1. A^1, Auxiliary tubes which are probably for the upper parts of the colony. H., Hydranths which give rise to branches and are connected with auxiliary tubes on S. S*, A transverse section of the stem in this position is shown in Fig. 4.

PLATE II.

Bimeria arborea. Collotype plate from a photograph by the author. × 1·4.



L. J. B. del. E. Wilson, Cambridge.



A New Method for Growing Hydroids in Small Aquaria by means of a Continuous Current Tube.

By

Edward T. Browne.

(University College, London.)

With one Figure in the Text.

The simple piece of apparatus, to which I give the name "Current-tube" was made last year in the Marine Laboratory at Plymouth. I designed it especially for growing Hydroids, and for them it has proved to be a success; but it should also be useful for other fixed organisms, such as sponges, polyzoa, and ascidians.

The previous methods which I had used for growing Hydroids in bell-jars or small aquaria never gave complete satisfaction. Occasionally a success was recorded, but there were too many failures, which frequently involved a great waste of labour.

A Hydroid colony when it has an ample food supply grows at an astonishingly rapid rate. I will give as an example of this the growth of *Syncoryne eximia* in one of my bell-jars at Plymouth in September, 1897.

The colony was taken on September 14th, and suspended in a bell-jar with one of its branches touching the glass. This branch sent out a shoot which attached itself to the glass and became converted into a stolon. The growth of the stolon and its lateral stolons or branches was measured and sketched daily from September 18th to 23rd, and on the 27th.

On September 18th the stolon was 14 mm. in length and had no lateral branches. Nine days later (September 27th) the main stolon measured 77 mm. in length, and its numerous lateral stolons or branches measured altogether 500 mm. These measurements excluded the short stalks of the hydranths, which were then seventy-seven in number. During the same period a second stolon came off from the old colony, and on September 27th it measured 70 mm. in

length and its branches 72 mm. The total amount of new growth in the part of the colony under observation amounted to 773 mm. (34 inches), and ninety-nine hydranths in thirteen days.

The rapid growth of this colony was due to a splendid food supply. The hydranths like large copepods, especially the oily *Calanus*, and there were no difficulties in obtaining a large supply almost every day. To give the hydranths every chance of catching the copepods, the side of the bell-jar to which the colony was fixed was placed facing a south window, but screened from direct sunlight, and only those copepods which are attracted by a strong light were put into the bell-jar. Consequently the copepods spent the day knocking their heads against the glass in the neighbourhood of the hydranths, and many got too close and were captured. During daylight the copepods usually kept near the surface and followed the course of the sun, but at night they could be brought amongst the hydranths by turning a strong beam of gaslight on to the colony.

I have frequently tried to grow *Bougainvillia* and some other Hydroids on the system described for *Syncoryne*, but have never met with a real success. A short stolon would run along the glass and a few hydranths would appear, but they remained in a diminutive condition. The new growth lacked vigour, which was evidently due to the want of food. Although there were plenty of copepods in the bell-jar the hydranths rarely caught them.

The tendency of the copepods to congregate within a small area was not always favourable to the colony, as the zone of the copepods did not always correspond with that of the colony. The introduction of the "plunger" system into bell-jars (described in this journal by the author in 1898) also proved useful for the growing of Hydroids. The currents which the plunger created helped to distribute the copepods more evenly in the water, and other species of copepods which are not attracted by light could be utilized for a food supply. The plunger in its journeys up and down a bell-jar does not set up a current in one direction, but in different directions, so that the copepods are carried hither and thither. It was the quick-changing direction of the current that frequently prevented the hydranths from holding their prey. One current carried a copepod upon the tentacles of a hydranth, and, before the tentacle responded to the touch, another current coming from a different direction would sweep the copepod away.

It must be borne in mind that the number of copepods or the quantity of plankton which can safely be placed into a bell-jar is strictly limited. Overcrowding soon leads to a heavy death rate, and ultimately to the fouling of the water. If copepods are being used

as food supply for Hydroids, then diatoms and other microscopic organisms should be present in the water for the copepods to feed upon. The constituents of the plankton require careful adjustment, and the whole must be kept in a perfectly healthy condition. There should always be a reserve of food in the bell-jar to carry over days of bad weather at sea and other misfortunes.

Hydroids certainly keep in better condition and live longer in a bell-jar with the water in constant motion than in perfectly still water. They are accustomed in the sea to a current running in a definite direction and carrying along plankton, from which they select their food. In the sea the current is ever running, always fresh and aerated, and always carrying new plankton. The successful rearing of Hydroids in a few gallons of water depends greatly upon imitating, as closely as possible, the natural conditions under which they live in the sea. The current-tube imitates fairly closely these conditions. The Hydroid is placed in a glass tube through which flows a constant current of aerated water carrying along with it the plankton in the bell-jar.

Description of the current-tube. The power for producing the current within the tube is compressed air. It does not matter by what method the air is compressed, provided that the pressure is kept fairly constant and the air is clean and pure. The latter condition is important, as a considerable quantity of air passes through the sea-water in the course of a day. The supply should be drawn from outside of a building, and then washed or filtered to remove the dust. The air-pump used in the Laboratory at Plymouth is a form of Sprengel's pump, made of metal, and obtainable for about ten shillings.* It is a remarkably cheap, but very efficient piece of apparatus.

I shall describe the current-tube as it was originally made by me. (Fig. 1). Modifications in size and shape will no doubt be introduced later on to meet special requirements.

A is a glass tube, 32 mm. in diameter and about 200 mm. in length. At the lower end a bored cork is inserted, into which is placed the narrow glass tube *B C D*, having an internal diameter of about 4 mm. *B C D* is an ordinary T-tube, with one end (*D*) reduced in length, one end (*B*) made U-shaped as figured, and the third end (*C*) remaining perfectly straight. To *D* is attached by a short piece of rubber-tubing the long glass tube *E*, the length of which depends upon the depth of the bell-jar. The next step is to tie a piece of string round the tube *A* near the top, and lower the current-tube into the bell-jar. The string attached to *A* is made fast to the top of the bell-jar, and adjustments made to hold *A* in an upright position.

* The pump is supplied by Anton Skell, Zinzendorfstrasse 34, Dresden.

A tall bell-jar was used, about 20 inches (50 cm.) in height and 8 inches (20 cm.) in diameter. The top of the tube *A* was about

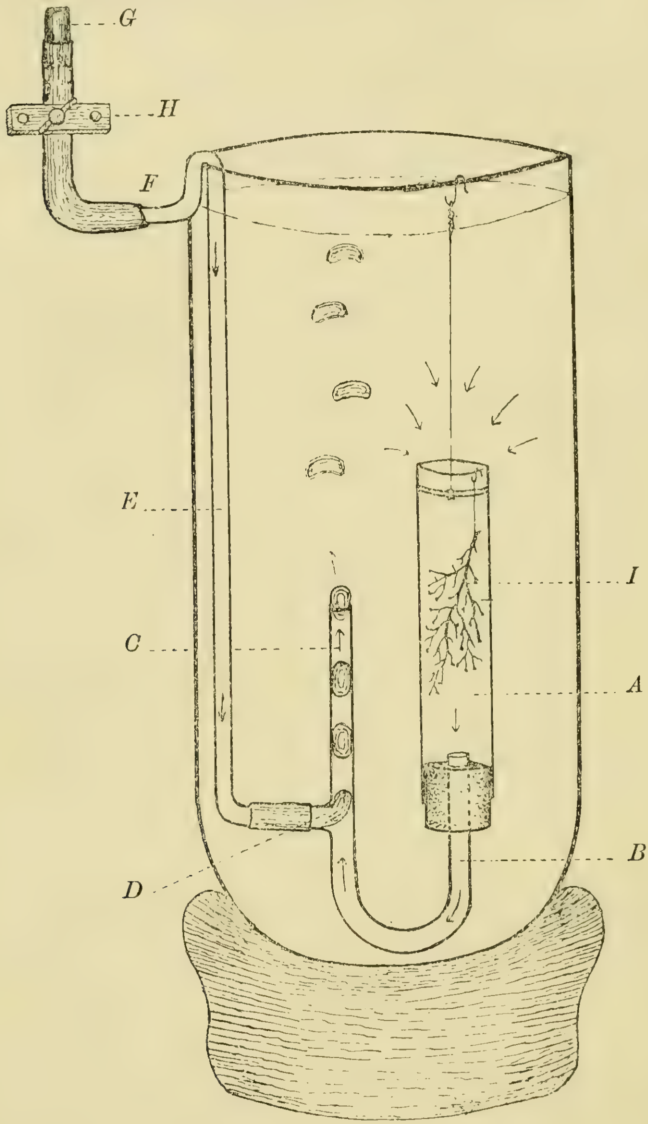


FIG. 1.

Diagram of the current-tube inside a bell-jar.

9 inches (23 cm.) below the surface of the water, which was about an inch below the top of the bell-jar.

After adjusting the current-tube, fill the bell-jar with sea-water, and connect tube *E* at *F*, with rubber-tubing, to the pipe *G*, supplying

the air from the pump. On the rubber-tubing near F should be fixed a screw compressor (H) to regulate the flow of air. On allowing the air to enter at F, it forces the water out of tube E down to D, and as the air enters tube C it breaks into bubbles, which pass up tube C and float to the surface. Between every two air-bubbles there is a short column of water. The driving of the water out of tube C by the air-bubbles produces an in-draught of water through tube A. As the air-bubbles follow one another in rapid succession, there flows down tube A a good current of water.

The Hydroid (I) is suspended inside tube A by a silk thread attached to a small glass hook, which hangs over the top of the tube; and the copepods, diatoms, etc., are put into the bell-jar.

As the current through tube A mainly draws from the upper part of the bell-jar, it is best to keep the top of the tube as low down as possible. The continuous stream of air which bubbles out of tube C not only aerates the water, but sets up a current inside the bell-jar and produces a good circulation. It is therefore advisable to keep the top of tube C low down. This circulation is beneficial to the plankton, and also carries it within the reach of the stream drawing in to tube A. The stream of air-bubbles is in another way of great service. Their continual breaking at the surface prevents the formation of the scum, chiefly due to bacteria, which gradually accumulates in small aquaria to form a thick, dirty surface film. This film, when once formed, is difficult to remove, and is often harmful to the inhabitants of an aquarium.

So long as the water in a bell-jar keeps quite clear there is no necessity to completely change it. I usually siphon off about half a gallon twice a week and fill up with very clean water.

The growth of Bougainvillia muscus *in a current-tube.* On November 6th a small bush-like colony of *Bougainvillia muscus*, about 20 mm. in length, was suspended inside a current-tube with the root of the colony touching the glass. The colony had a few short stolons growing out from near the distal ends of the branches. It was for observations upon the growth and function of these stolons that the *Bougainvillia* was placed in the tube.

Soon it was apparent that *Bougainvillia* liked its new surroundings. The hydranths kept fully extended, and their stomachs were seldom empty. The stolons greatly increased in number and in length, some hanging down 15–20 mm. A few developed, here and there, solitary diminutive hydranths, but there were no signs of active budding of hydranths. The activity of the colony was directed into a stolon which came off from near the root and was able to attach itself to the glass of the tube, along which it grew at a

great rate, sending out lateral stolons and quickly producing large hydranths.

A most fascinating and beautiful sight was to see the colony at night under a low-power lens, illuminated by a strong light against a black background, and to watch the fate of the copepods as they passed down the tube. Usually the copepods on entering the tube either were carried clear of the colony, or going among the hydranths succeeded in escaping into the narrow tube, and then were rapidly ejected along with the air-bubbles. As the current through the tube was fast enough to pass the whole of the water in the bell-jar through several times during the day, the copepods, which escaped on their first round were liable to a few more passages of the tube, until their fate was settled by the hydranths which had recently emptied their stomachs.

On watching the copepods passing through the tube, it was clearly seen how a steady, continuous current in one direction was of advantage to the hydranth in securing a copepod. A copepod would be seen to drift on to the expanded tentacles. If at the moment of touching the copepod gave a jump it usually got away, but occasionally the jump was delayed too long, and pressed by the current against the tentacles, it remained just long enough to be secured.

As my stay at the Laboratory terminated on November 17th, I was only able to watch the growth of the colony for eleven days, and during that period the new growth far surpassed that of any *Bougainvillia* which I had previously tried to grow. Mr. L. R. Crawshay most kindly took charge of the colony, and I am able to give a further account of the growth from his letters to me.

Letter dated November 30th :—"The colony has been kept well fed with copepods every day. The air-pump continues to work successfully, so that the food supply has been continuous. The growth of the colony has consequently been very rapid, more especially, or almost entirely, over the basal stolon, which by yesterday had extended over the whole length of the tube, lining the main expanse of the interior surface. Young polypes have grown out from this surface at every part, and almost without exception at or near the points where branching of the stolon occurs. But so far as I have observed the polypes are simple; there is no tendency to a tree-like expansion anywhere. The parent part of the colony has not developed."

"The colony has developed enemies; from what source I know not, whether from veligers in the tow-nettings or from original infection. Three days ago three minute nudibranchs were first observed browsing on the hydranths, which proved to be *Tergipes despectus*. Yesterday

the number had increased to six, and now the survival of the colony is threatened by about thirty capsules of their spawn deposited all over it."

Letter dated December 18th :—" Shortly after my last letter to you, a day or two only, it was evident to me that the six *Tergipes* were having it all their own way. They had stripped the whole stolon area of almost every visible polype, and had, moreover, simply plastered the same with spawn, containing, I should say, thousands of their embryos. I therefore took out the tube and removed the *Tergipes*, and thoroughly cleaned out the bell-jar before returning the Hydroid colony. The effect was very marked. In about two days the polypes sprung up again in all directions, and the stolon continued to form a closer network inside the tube. But it is even now to all intents and purposes a creeping colony. The first show of arborescent growth occurred inside the tube. This happened after the stolon had reached the summit of the tube and ramified over the edge. A few days ago a similar branching growth appeared outside the tube at one spot. But this is quite insignificant, with only about three polypes, and no more than 10 mm. in height."

"A new source of obstruction has arisen in the form of a brown diatom, which in the past few days has come to infest almost the whole interior of the tube."

Early in February, 1907, I heard that the colony was still alive, but owing to the intermittent failure of the air-pump and the scarcity of copepods the colony had not put forth much new growth.

In March the growth of diatoms and a small alga (*Ectocarpus*) inside the tube was slowly choking the colony. A few vegetarian molluscs were placed on the tube to browse on the algæ. They did more than was expected of them in cleansing the tube. Within a fortnight of their introduction the encrusting mass of diatoms, etc. lining the tube broke away in large flakes, perhaps due to a poison secreted by the molluscs, and carried away at the same time the stolons to such an extent that the whole colony was destroyed.

The successful growing of *Bougainvillia* is not altogether due to the advantages of the current-tube, but greatly also to the personal attention which Mr. Crawshay bestowed upon the colony. I sincerely thank him for the interesting letters from which he has allowed me to quote.

I am also greatly indebted to Dr. Allen. It was during the preliminary testing of his air-pump that the current-tube was designed. He at once most generously gave me the use of the pump, and took a very active interest in the starting of the apparatus and in the welfare of the colony.

A Peculiarly Abnormal Specimen of the Turbot.

By

J. T. Cunningham, M.A., F.Z.S.

With Plate III.

The specimen which forms the subject of this note was sent to Dr. Allen by Miss Olivia L. Fox, of Falmouth, at the beginning of December, 1906, preserved in formalin. Dr. Allen sent it to me in London, and requested me to study and describe it. The specimen is 4·4 cm. in length, and presents a condition which has never previously been described in any species of flat-fish. I have examined it with great interest, and would express here my thanks to Dr. Allen for sending it to me.

With respect to the position of the eyes the fish is a reversed specimen, that is to say, both eyes are on the right side, whereas normally in turbot they are on the left. With respect to colour, on the contrary, the specimen partially resembles a normal turbot: the right side is almost entirely unpigmented, the greater part of the left side is coloured as in a normal specimen. The pigmentation does not extend uniformly over the whole of the left side, but is absent from the head, and from the anterior part of the dorsal region above the head. On these areas there are only a few scattered black chromatophores. On the right or uncoloured side there are also scattered black chromatophores, rather more numerous than on the left side of the head. It is important to note that the head and anterior region of the right side, although not fully pigmented, have more pigment than the rest of that side: between the eyes and around the dorsal eye pigmentation is almost complete.

The number of dorsal fin-rays in the specimen is 65, of the ventral 47. The characteristic tubercles of the adult turbot are not yet developed, but there are three little projections at the base of each of the dorsal and ventral fin-rays, and also projections at the bases of the caudal rays: these are probably the beginnings of marginal tubercles.

The anterior end of the dorsal fin, and the basal tissue which carries

it, form a projecting hook-like process over the dorsal eye, that is, the originally left eye which has moved to the right side of the head. This projection, due to the absence of attachment between the base of the fin at the anterior end and the head, occurs commonly in ambicolorate specimens of the turbot, and less frequently in ambicolorate specimens of other species of Pleuronectidae. (See Cunningham & MacMunn, "Coloration of Skins of Fishes," etc., *Phil. Trans.*, 1894.)

The specimen was caught by Miss Fox on September 28th last year, on the sands at Polzeth, near the Doom Bar, Padstow, and was kept alive in captivity till November 28th, when it died. When the fish was alive the right side, on which the eyes are situated, was of course the upper side, while the left was in contact with the ground. It presented, therefore, the extraordinary case of a flat-fish having its upper side white and its lower side coloured. Several normal specimens were seen with the abnormal one, and some were caught; one of these was sent with the abnormal specimen for comparison. The normal specimen was 4·2 cm. long; its metamorphosis was complete, but there were still a few scattered black chromatophores on its right or lower side. Similar chromatophores are present on the right or upper side of the abnormal specimen, and they are a little larger and more numerous. Miss Fox, in a letter, stated that the upper side of this specimen was becoming pigmented during the time she kept it alive, but it is evident that exposure of this side to light had produced very little effect up to the time of death. However, it is not impossible that, had the fish lived to become adult, its upper side would have become completely coloured in consequence of exposure to light, since I have proved by my experiments on flounders that light produces pigment on the lower side of normal flat-fishes. In that case the specimen would have been quite similar to the ambicolorate turbot, or specimens coloured on both sides, which have long been known, except that the present specimen would still be reversed.

The appearance of the two sides of the fish is shown in the two figures here given, which are reproduced from photographs taken by my friend Mr. E. T. Browne, of University College, London. I have discussed the condition of the fish at greater length in a paper in the *Proceedings of the Zoological Society*, 1907, p. 174. I have there pointed out that the condition, which is certainly congenital, is that of a turbot of which the head is reversed while the body remains normal. In other words, the fish consists of a reversed head joined to a normal body. The abnormal position of parts in the fish must be regarded as due to the abnormal position of corresponding parts in the ovum from which it was developed. The determinants of the left side of the head were on the right, and vice versa. I have suggested that

this view may explain the separation of the anterior end of the dorsal fin from the head, which occurs in this specimen and in many ambicolorate specimens. In consequence of the reversion of the head the left side of the body is joined to the right side of the head and vice versa. Thus the dorsal fin, when it grows forwards in the development, finds itself in abnormal relation to the two sides of the head and therefore fails to unite with the head, but grows out as a free process. The pigmentation of the fish is not precisely in agreement with the above hypothesis, since the right side of the head is only incompletely pigmented, and pigment is wanting from the anterior dorsal region of the left side of the body. These deficiencies of pigmentation, whatever their cause, do not appear to me to be sufficient to invalidate my hypothesis, which agrees so well with all the more important peculiarities of the fish.

EXPLANATION OF PLATE III.

Fig. 1. Right or upper side of abnormal young Turbot, showing both eyes with some pigment on right side of head, absence of pigment from right side of body.

Fig 2. Left or lower side of the same specimen, showing absence of eyes and pigment from left side of head, presence of pigment over left side of body.

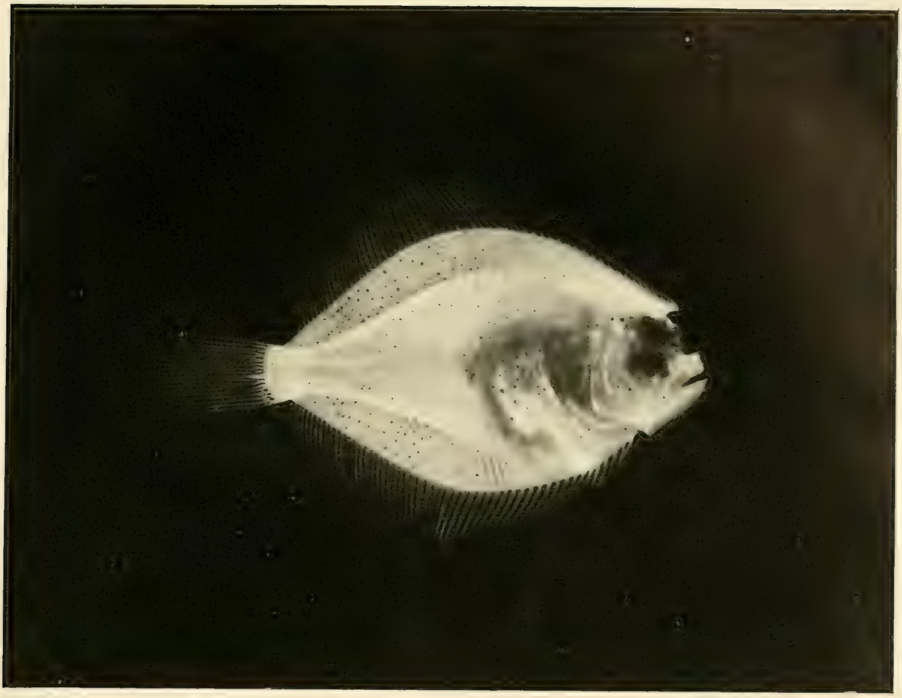


Fig. 1.

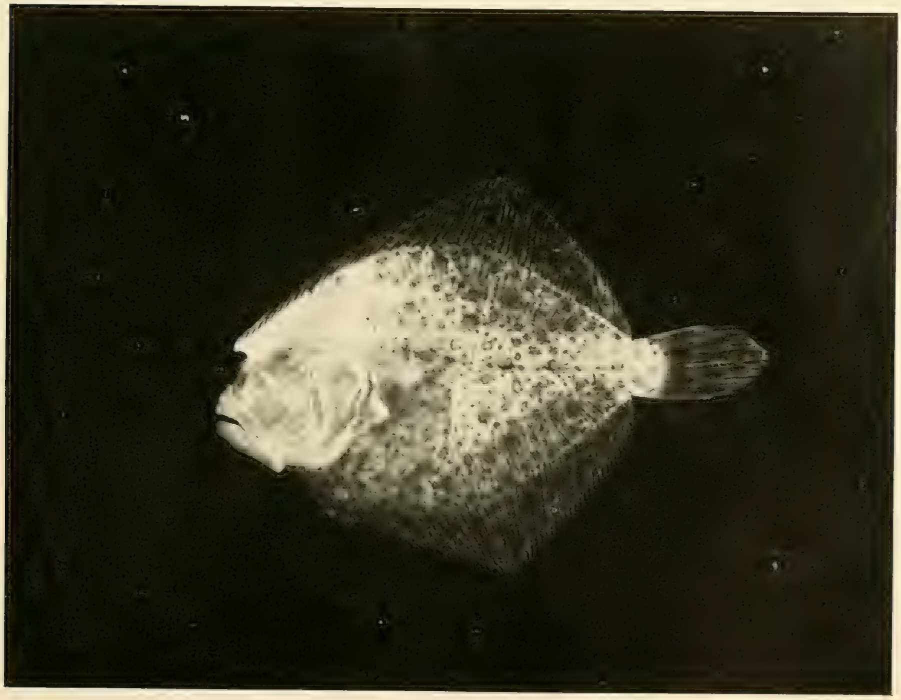


Fig. 2.

On Phellia murocincta (*Gosse*).

By

Chas. L. Walton.

P. H. Gosse described this beautiful little species in his *British Sea Anemones and Corals*, in 1860, from two specimens obtained from a pool at Petit Tor, near Torquay.

I recently collected two specimens at Zennor, some five miles along the coast south of St. Ives, Cornwall.

An examination of these proved that Gosse's examples were young and immature, as shown by the difference of size and number of tentacles.

Their habitat was very similar to that of the Torquay specimens, namely, attached to the under side of granite stones, at the bottom of a shallow pool in a small dark cave, just at the top of the Laminarian zone. There occurred also on the same stones young specimens of *Actinia equina* (Linn.), *Cereus pedunculatus* (*S. Bellis*), and a number of *Depastrum cyathiforme*.

Size.—Expanded, half an inch in diameter. The measurements of Gosse's examples were, "Diameter of column $\frac{1}{8}$ of an inch, expanded $\frac{1}{6}$ of an inch."

Outline of base irregular. The "epidermis" not dense (as in Gosse's description), free and easily removed, the animals expanding as freely after the removal as before. The column was usually much flattened during the day, but frequently elongated and pillar-like at night.

No acontia were emitted even after severe irritation.

Tentacles 36 in number. Gosse's specimens had 24. Otherwise the tentacles in my specimens agreed with his account. As he says, "they were generally carried hanging over the margin with a double curve, like the branches of a chandelier, but sometimes the inner row stand erect."

They exhibited much greater activity at night than during the day-time.

Colour.—Although differing slightly from one another, both my specimens agreed with Gosse's, except that the column had no "mealy

appearance and fewer white longitudinal lines," nor were there "broad white gonidial radii" on the disk, though the white patches at the bases of the tentacles were in one specimen much more prominent in the case of the "gonidial tentacles" and those adjacent, than the rest.

The white star-shaped area in the centre of the disk was very well marked in one specimen, less so in the other, and the three white bars on the tentacles varied considerably in intensity.

One of the anemones twice moved from the upper to the under side of the stone to which it was attached, when this had been turned up for inspection.

The colouring of these anemones harmonised so exactly with their surroundings (granite stones covered with live and dead colonies of *Polyzoa* and *Serpulæ* brown and white—the rock also being stained dark brown in patches)—as to be very hard to make out even when in the aquarium and close under the eye—especially when fully expanded.

Marine Biological Association of the United Kingdom.

Report of the Council, 1906-7.

The Council and Officers.

Four ordinary and two special meetings of the Council have been held during the year, at which the average attendance has been twelve. The Council desire to express their thanks to the Royal Society, in whose rooms at Burlington House the meetings have been held.

Committees of the Council have visited the Laboratories at Plymouth and Lowestoft and inspected the details of the work which is being carried on.

In November, Lord Carrington, President of the Board of Agriculture and Fisheries, visited the Lowestoft Laboratory, and was entertained by the members of the Council at luncheon.

In December, a deputation to the Chancellor of the Exchequer in support of an application for funds to carry on the work of the Association, was organized by the Council. The deputation was introduced by Mr. Austen Chamberlain, M.P., and was received by Mr. M'Kenna, M.P., Financial Secretary of the Treasury, in the unavoidable absence of Mr. Asquith. As a result of the Council's application the usual grant to the Association for the purposes of the Plymouth Laboratory was renewed, and the Council were asked to continue to carry out the work of the International Investigations until July 1908.

The Council have to record with deep regret the death of Professor Alfred Newton, a Vice-President since the foundation of the Association; and of Sir Michael Foster, K.C.B., also a Vice-President, and for many years the representative of the University of Cambridge on the Council. One of Sir Michael Foster's last public utterances was made at the deputation to the Chancellor of the Exchequer, when he warmly advocated the claims of the work of the Association on the financial support of the Government.

The Laboratories.

The Laboratories at Plymouth and at Lowestoft have been maintained in an efficient state, and both are well equipped for the work which they undertake.

The Boats.

The *Oithona* and *Huxley* have both worked successfully during the year, and have given great satisfaction to those who have conducted the experimental work at sea.

The sailing-boat *Anton Dohrn* was again used during the winter months for collecting work in connection with the Plymouth Laboratory. It would add to the efficiency of the winter work if this boat could be replaced by a small motor fishing-boat, which would be better able to take advantage of fine weather during the winter months.

The Staff.

Mr. W. Bygrave, B.A., of Christ's College, Cambridge, has succeeded Dr. Gough as Assistant Naturalist for Plankton Investigations, on the appointment of the latter to the post of Assistant in the Pretoria Museum.

Mr. C. L. Walton has been appointed a temporary Assistant Naturalist at Lowestoft for work on the steamer *Huxley*.

Occupation of Tables.

The following Naturalists have occupied tables at the Plymouth Laboratory during the year:—

Miss A. Binder, Mainz (Hydrozoa).
E. T. Browne, M.A., London (Medusae).
A. D. Cotton, Kew (Algae).
A. H. Craig, London (General Zoology).
A. D. Darbishire, M.A., London (Elasmobranchs).
W. De Morgan, London (Crustacea).
Sir Charles Eliot, K.C.M.G., Sheffield (Nudibranchiata).
E. S. Goodrich, M.A., F.R.S., Oxford (Anatomy of Fishes).
G. H. Grosvenor, B.A., Oxford (General Zoology).
T. V. Hodgson, Plymouth (Pycnogonida and Crustacea).
Keith Lucas, M.A., Cambridge (Physiology of Crustacea).
F. A. Potts, B.A., Cambridge (Parasitic Crustacea).
Miss M. Robinson, London (Hydrozoa).
R. W. H. Row, London (Crustacea).
C. Shearer, PH.D., Montreal (Polychaeta).
E. Speyer, Eton (Hydrozoa).
W. M. Tattersall, B.SC., Dublin (Plankton).
A. Willey, D.SC., F.R.S. (Polychaeta).

Sixteen students attended a course of study in Marine Biology conducted at the Laboratory during the Easter vacation by Mr. G. H. Grosvenor.

The Library.

The thanks of the Association are due for the following books and current numbers of periodicals presented to the Library during the past year:—

Académie Imp. des Sciences de St. Pétersbourg. Bulletin.
—— Mémoires.
American Museum of Natural History. Memoirs.
—— Report.
American Philosophical Society. Proceedings.
Australian Museum. Memoirs.
—— Records.
—— Report.
Bergens Museum. Aarbog.
—— Aarsberetning.
—— An Account of the Crustacea of Norway, etc.; by G. O. Sars.
—— Meeresfauna von Bergen.
Bernice Pauahi Bishop Museum, Honolulu. Occasional Papers.
Board of Agriculture and Fisheries. Annual Report of Proceedings under the Salmon and Freshwater Fisheries Acts.
—— Annual Report of Proceedings under Acts relating to Sea Fisheries.
—— Report of Proceedings of 16th Annual Meeting.
Boston Society of Natural History. Proceedings.
Bristol Naturalists Society. Proceedings.
British Association for the Advancement of Science. Report.
Brooklyn Institute of Arts and Sciences. Cold Spring Harbor Monographs.
—— Science Bulletin.
Brown University. Contributions from the Anatomical Laboratory.
Bryn Mawr College. Monographs, Reprint Series.
Buffalo Society of Natural Sciences. Bulletin.
Cairo Zoological Gardens. Report on Mission to Europe, 1905.
Cambridge Natural History. Protozoa, Coelenterates, Echinoderms, etc.
The Carnegie Institution. Publications.
—— Announcement of Station for Experimental Evolution.
La Cellule.
Ceylon Marine Biological Laboratory. Report.
Ceylon Pearl Oyster Fisheries. Report to Colonial Government.
College of Science, Tokyo. Journal.
College voor de Zeevisscherijen. Verslag van den Staat der Nederlandsche Zeevisscherijen.
Colombo Museum. Spolia Zeylanica.
The Commissioners of Fisheries, N. S. Wales. Report.
—— The Fishes of Australia. By D. G. Stead.
Conchological Society of Great Britain and Ireland. Journal of Conchology.
Conseil perm. internat. pour l'Exploration de la Mer. Bulletin des Résultats acquis pendant les Courses Périodiques.
—— Bulletin Statistique.
—— Publications de Circonstance.
—— Rapports et Procès-Verbaux des Réunions.
—— Rapport Administratif.
Cuerpo de Ingenieros de Minas del Peru. Boletin.
—— Segunda Memoria.

Danish Biological Station. Report to the Board of Agriculture.
Kgl. Danske Videnskabernes Selskab. Oversigt.
—— Skrifter.
Dept. of Agriculture, Cape of Good Hope. Marine Investigations in S. Africa.
Dept. of Agriculture, etc., Ireland. Reports.
Dept. of Marine and Fisheries, Canada. Annual Report.
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To the authors of the Memoirs mentioned below the thanks of the Association are due for separate copies of their works presented to the Library:—

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General Work at the Plymouth Laboratory.

Faunistic work during the year has been chiefly directed to extending the observations into the deeper water of the English Channel. A close study has been made of the grounds to the south of the Eddystone as far as the fifty-fathom line. The results of this survey are now being worked up, and it is hoped to publish them in an early number of the Journal.

In August last the *Oithona* was sent to the North Sea in order to carry out fishery investigations in the shallow inshore waters of the East Coast, for which she is specially suited, whilst the *Huxley*, after the completion of the regular August hydrographic cruise, made a short voyage to the deep water on the edge of the Bay of Biscay, south of Parson's Bank. In addition to hydrographic observations, several hauls of the Agassiz trawl were made at depths of from ninety to four hundred fathoms, and some very interesting material was collected. This is now being studied by different specialists, and their reports will add some valuable information to our knowledge of these little-worked grounds.

In connection with the more local faunistic work in the immediate

neighbourhood of Plymouth, the Director has continued to pay special attention to the Polychæta, whilst Mr. Crawshay is commencing a study of the Sponges.

Mr. G. E. Bullen has continued from time to time the observations on the food of the mackerel and other migratory fishes. Since the present spring mackerel season has been characterized by the immense abundance of fish, whilst last year they were very scanty, a comparison of the physical and biological conditions of the two periods is of great interest.

Mr. T. V. Hodgson has occupied a table in the Laboratory during the whole year, and has been engaged in working out the material which he collected in the Antarctic.

The International Fishery Investigations.

The following is a summary of the work done, and of the conclusions arrived at by the scientific staff working under the direction of the Council.

Section I.—NORTH SEA WORK.

A. WORK OF THE S.S. "HUXLEY."

Trawling Investigations.—From June 1906 to the end of May 1907 the *Huxley* made 15 fishing voyages, during which 198 hauls of the large commercial trawls were made in connection with the scientific survey in progress. The boat was again laid up at Grimsby during December and January.

From the beginning of the investigations 90 voyages have been completed by the *Huxley*, and the result of 1,078 hauls with the large trawls systematically recorded. On many occasions fine-meshed nets have been attached outside the cod-end, and other parts of the commercial trawl, in order to throw light on the proportions of small fish which escape through the meshes.

In August 1906 a temporary exchange of steamers was effected between the Lowestoft and Plymouth Laboratories, in order to facilitate an investigation of the Thames Estuary, which was carried out very satisfactorily by the s.s. *Oithona*. Two members of the Lowestoft staff had charge of the work, and were kindly assisted by Dr. James Murie, of Leigh, Essex, who was present on board the vessel throughout the voyage. The otter trawl was shot on 44 occasions.

Fish Measured.—More than 100,000 measurements of fish, representative of the total catch on almost every occasion, were made and recorded at sea during the past year.

Nearly 410,000 fishes have been measured under these conditions since the beginning of the investigations, as shown in detail in the following table:—

		Plaice.	Haddock.	Others.		Totals.
1902–6	Voyages I–LXXV	90,463	26,705	181,660	...	298,828
1906–7	Voyages LXXVI–XC	17,151	20,535	71,633	...	109,319
	Totals	107,614	47,240	253,293	...	408,147

In order to supplement the *Huxley's* measurements of plaice during the spawning season, and to compare her results with those of commercial trawlers during this season, a voyage on a Lowestoft smack was made by a member of the staff in February last, and the entire catch of plaice (2,631 fish) was measured and examined. During January and February two members of the staff also measured and examined 19 samples of plaice, amounting to 8,208 fish, from smacks in Lowestoft market.

Marking Experiments.—During the past year 2,053 marked plaice have been set free, as compared with 2,041* during the previous twelve months (1905–6). Of the latter fish 522 have been reported as recaptured by May 31st, 1907, i.e. 25·6 per cent of the total liberated, as compared with 23·9 per cent reported last year for the 5,115 marked plaice previously liberated.

The correspondence of these percentages renders it highly probable that under similar experimental conditions the percentage of recaptures of marked plaice affords a reliable factor for estimating the intensity of fishing in a particular area under modern conditions, and for measuring differences in this respect in different regions.

The annual percentage of marked fish returned has been found to vary with the size of the fish, increasing regularly from less than 10 per cent for plaice marked at less than 20 cm. (8 inches) in length to a maximum which lies between 30 per cent and 45 per cent in the case of plaice marked at 30–39 cm. (12–15 inches) in length. Above this size the percentage again decreases, a result which appears from other data to be partly indicative of natural mortality.

In this connection it is not without interest that during the spawning season of the plaice the males have been caught in relatively greater numbers than the females, not only among the marked fish, but also in the ordinary course of the trawling experiments in spawning areas.

The transplantation experiments to the Dogger Bank, which were again carried out in the spring of 1906, have shown nearly the same rapid growth of plaice which was so marked a result of the experiments

* This total was given in last year's report as 2,042, owing to accidental inclusion of a marked dab.

in 1904. On the other hand, experiments on the coastal banks and on the Flamborough Off Grounds have shown that in the western part of the North Sea the area of rapid growth is apparently limited to the Dogger Bank, and does not extend to the grounds south or west of the Dogger Bank.

The following table summarizes the chief results obtained from these experiments as to the average annual increase in length of small plaice, the great majority of which ranged between 19 and 23 cm. in length at the time of liberation.

EXPERIMENT.	ANNUAL INCREMENT.
Dogger Bank, 1904 . . .	15 cm.
„ „ 1905 . . .	10 cm.
„ „ 1906 . . .	13 cm.
Leman Banks, 1905 . . .	6 cm.
Flamborough Off Ground, 1906 .	7 cm. (nearly).
Well Bank, 1906 . . .	6 cm. (nearly).

Data yielded by the trawling experiments and fishermen's records, as well as by the investigations made concerning the food of fishes, render it highly probable that the above variations in the growth of plaice on the Dogger Bank are mainly due to competition for the same articles of food between this fish and the haddock. Young haddock were much more abundant in 1905, when the growth of plaice was relatively small, than in either of the years before or after.

The transplantation experiments to the Dogger Bank have been again repeated during the spring of the present year, and have been extended to certain grounds on the Great and Little Fisher Banks.

The experiments devised last year to test whether still smaller plaice of a length of 2–4 inches would thrive if transplanted to the Dogger Bank have been unsuccessful.

Experiments with marked fish have also been carried out upon certain other species besides the plaice, as shown in the following table:—

FISH.	NO. MARKED.		NO. RECAUGHT.
Sole . . .	463	...	23
Brill . . .	33	...	7
Turbot . . .	11	...	7
Lemon Sole . .	15	...	6
Flounder . .	17	...	1
Dab . . .	12	...	2
Cod . . .	252	...	40
Haddock . .	44	...	1
Whiting . . .	1	...	—
Pouting . . .	1	...	—
Latchet . . .	30	...	2
Red Gurnard . .	18	...	—
Thornback Ray . .	108	...	26

It will be seen that in spite of many trials, the sole has not proved a very suitable subject for experiments of this kind, as the number of recaptures has been excessively small compared with the labour involved. On the other hand, the experiments with other flat-fish, especially brill, turbot, and lemon sole, have been very satisfactory, and merely require to be carried out on a large scale in order to yield results of interest comparable with those of the plaice.

The experiments with cod and thornback, though not so numerous as is desirable, have yielded results of great value, both as regards the migrations and rate of growth of these fishes; and the two recaptures of marked latchet have also shown features of considerable interest.

Marked Coconuts and Drift Bottles.—With the object of obtaining additional data on the relative intensity of trawling in different parts of the North Sea, 859 perforated coconuts, to each of which a numbered brass label was attached, were thrown overboard from the *Huxley* in September last. They were put out at equal intervals of one mile along lines which traversed the chief fishing grounds of the Lowestoft smacks as well as the Dogger Bank and the grounds east and west of it. Many of these nuts have been returned to the Lowestoft Laboratory by fishermen and the Association's agents with particulars of capture, but a complete year must elapse before it would be profitable to compare the records.

Of the bottles designed by Mr. Bidder for the study of bottom currents, 170 were put out along three lines in the southern part of the North Sea in November and December. Mr. Bidder has communicated to the International Council an account of some results of former experiments carried out on the *Huxley* with these bottles. In these experiments the bottles were recovered by commercial trawlers over all the area at the rate of 54 per cent per annum, while in particular districts the rate of recovery was even higher.

B. LABORATORY WORK.

Age of Plaice.—A detailed report on the age of plaice based on the examination of nearly 8,000 otoliths collected up to the end of 1905, has been completed and is now in the press.

The report, besides demonstrating the reliability of the methods of age-determination employed, contains definite information in regard to

1. The distribution of the various age-groups in the southern part of the North Sea.
2. The relation of size to age on different fishing grounds.
3. The rate of growth of young plaice on the English inshore grounds.

4. The average rate of growth of plaice in the southern part of the North Sea at different ages, and the difference between the sexes in this respect.
5. The relative numerical proportions of the two sexes at successive ages.
6. The age and size at first maturity.

FOOD OF FISHES. The stomachs of over 10,000 fishes belonging to 34 species have now been examined, and a second detailed report on the food of fishes is in the press.

Among the more important observations it contains may be mentioned those on

1. The predominant extent to which Crustacea serve as food for almost all useful species of fish during their earliest stages, and the degree to which the different species of fish diverge in their selection of food as they grow older.
2. The cessation of feeding by flat-fish, especially plaice, during the winter months, and the relation of this phenomenon to spawning and other conditions.
4. The competition between plaice, haddock, and dabs for molluscan food, especially on the Dogger Bank, and the great destruction of molluscan fry by these species, particularly by the haddock.

BOTTOM FAUNA AND BOTTOM DEPOSITS.—The analysis of this material has made continual progress, and the results are in process of collation.

HERRING INVESTIGATIONS.—Several additional samples, each of 100 fish, including one sample from the Cornish coast, have been examined in conformity with the scheme described last year. All the samples show a high degree of uniformity as regards the number of vertebræ.

C. FISHERMEN'S RECORDS.

This branch of the work has been continued on the same lines and on the same scale as hitherto.

The records of Lowestoft trawling smacks so far as concerns the catch of plaice and soles have been worked up for each of the past four years so as to show the average catch per haul for each month in succession, and for each of nine grounds into which the total area has been subdivided.

The results show clearly the seasonal fluctuations in the catch on different grounds, and harmonize remarkably well with the results of the *Huxley's* marking and other experiments in the same region.

Section II.—HYDROGRAPHIC AND PLANKTON WORK IN THE ENGLISH CHANNEL.

The Hydrographic programme of previous years has been carried out on the quarterly cruises in the English Channel, and the results up to the end of September 1906 have been published in the Bulletin. The work has been rendered unusually difficult by bad weather, and only one set of current measurements has been made. Severe gales made it impossible to complete the November cruise, and the three stations to the east of the Isle of Wight were omitted. The area is to a certain extent covered by the lines of samples taken by steamers sailing from Southampton and Newhaven.

Fortnightly samples and observations of Surface Temperature have been received from the captains of steamers crossing the English Channel, and from five lightships. Outside the English Channel, regular samples have also been received from the captains of liners, covering the North Atlantic south of 56° N. latitude.

The salinity of the English Channel has been slowly decreasing during the past year, the decrease beginning in the western half which is influenced by the southerly flow of fresher water from the Irish Sea. This flow was well marked during February, but no division into layers of different salinity was found at any of the stations. In the eastern half of the Channel the change did not commence till three months later, water of 35·4 $^0/_{00}$ S. being still found on the Newhaven-Caen line during the latter half of April.

The decrease in salinity referred to in a previous report has continued.

In May 1906 there was a very decided fall over the whole of the English Channel. The salinity at Station 3, off Ushant, increased fairly regularly with the depth, being 35·21 $^0/_{00}$ at the surface and 35·34 $^0/_{00}$ at 110 metres. This difference is apparently due to the coastal water of Brittany, and is not connected with the sharp division into layers that is sometimes found on the more westerly stations. At all other stations during May the water was homogeneous from top to bottom.

During the two following months the decrease of salinity still continued, and no value as high as 35 $^0/_{00}$ was found on the Newhaven-Caen line during the latter part of July.

The August cruise showed a strong southerly flow from the Irish Sea across the western entrance to the Channel and a decided division into layers of different salinity on all the western stations except the one off Ushant. The differences between the surface and bottom salinities were greatest on the more northerly positions, especially off

the Bishop and in the Bristol Channel. The Plankton on the western stations was unusually rich in oceanic species, a fact which leads to the conclusion that this southerly current is accompanied by and probably due to a simultaneous movement of water from the Bay of Biscay in a northerly direction.

By November 1906 the surface salinity of the English Channel had risen generally, the 35·4 isohaline in the western area roughly coinciding with the August isohaline of 35·3, while to the east of the Isle of Wight–Cherbourg line the area which during the August cruise had a salinity of 35·0 to 35·1 was filled with water of from 35·1 to 35·2. The southerly flow of low salinity water from the Irish Channel to the west of the Scilly Islands was even more sharply defined on its eastern edge than in August. It extended at least as far south as Parson's Bank, where the surface salinity was 35·33 compared with 35·37 in August. The western edge lies outside the area of the quarterly cruises, and the only observations available are from liners which only cross its northern extremity. Its approximate dimensions on the surface south of the latitude of Land's End may be put at 100 miles in a north and south direction, and 25 to 30 miles across. It reached the bottom at all stations except 4 and 5, where its thickness was about 30 metres, the water below that depth being of higher salinity. In view of the steep salinity gradient to which this current frequently gives rise on the surface, and its possible importance to the Plankton investigations, it would be advisable to devote a special cruise of three or four days to its examination, particularly on its western edge.

The samples from the February cruise have been analysed, but the results have not yet been plotted. The most striking point is the continued fall of the salinity on Station 4 (Parson's Bank), accompanied by a rise at Station 5. The water was of the same composition at all depths.

Two stations were worked south-west of the Start at the end of March, when mackerel were being caught by trawlers on the bottom. The results were much the same as in February, and present no point of interest.

In May five new stations in the Bristol Channel were added to the programme. It had originally been intended to work this area on the same day on which the steamers of the Irish Fishery Department and the Lancashire Sea Fisheries Committee were to carry out similar investigations in the adjacent waters, but this was unfortunately prevented by a gale which interrupted operations for some days.

During the year samples of Plankton were taken as usual on the four quarterly cruises, and also at frequent regular intervals at Plymouth, and at several light-vessels off the English and Irish coasts.

Samples were also taken each week midway between Plymouth and the Channel Islands, from the s.s. *Devonia*.

The records of the species found on each of the quarterly cruises are published in the Bulletin of the International Council.

As in the preceding years, it was found that the percentage of Oceanic species in the Plankton falls regularly as one passes up the Channel from west to east, rising again a little to the east of the Cherbourg–Southampton line.

In August 1906 the Pteropod *Limacina lesueuri* (D'Orbigny) was found in vast numbers at the surface in the north-west portion of the English Channel, and to the north of the Scilly Islands.

This Pteropod, which Professor Paul Pelseneer was good enough to identify, is an inhabitant of tropical waters, and has not previously been recorded north of the Bay of Biscay, so that its appearance in the Plankton would seem to indicate an inflow of water of southerly origin.

It is possible that the shoal entered the Channel from the south-west, following the direction of the strong current which at times flows past Ushant, in a northerly direction.

As no Plankton samples were taken in the south-west portion of the Channel between May (when *Limacina* was entirely absent from the Plankton) and August 1906 it is not possible to obtain any confirmation of this supposition.

At the end of August 1906 an extra set of Plankton samples was taken about 60 miles south-west of Parson's Bank.

These samples contained a number of forms which had not been found on any of the quarterly cruises.

Published Memoirs.

The following papers, either wholly or in part the outcome of work done at the Laboratory, have been published elsewhere than in the Journal of the Association :—

Bidder, G. P.—*Principal Results of the Experiments with Bottom-Trailers.* Rapp. et Proc. Verb. Cons. Internat p. l'explor. de la mer, vol 6., 1906, pp. xxxv.–xlii.

Chubb, G. C.—*The Growth of the Oocyte in Antedon : A Morphological Study in the Cell-Metabolism.* Phil. Trans. Roy. Soc., Ser. B, vol. 198, 1906, pp. 447–505.

Cotton, A. D.—*On some Endophytic Algæ.* Journ. Linn. Soc. Botany, vol. 37, 1906, pp. 288–297.

Davenport, C. B.—*Evolution without Mutation.* Journ. Experim. Zool., vol. 2. 1905, pp. 137–143.

Hewett, C. G.—*Ligia.* Liverpool Marine Biology Committee. Memoir xiv., London, 1907.

PACE, R. M.—*On the Early Stages in the Development of* FLUSTRELLA HISPIDA *(Fabricius), and on the Existence of a "Yolk Nucleus" in the Egg of this Form.* Quart. Journ. Micr. Sci., vol. 50, 1906, pp. 435–478.

ROBINSON, MARGARET.— *On the Development of* NEBALIA. Quart. Journ. Micr. Sci., vol. 50, 1906, pp. 383–433.

SHEARER, CRESSWELL.—*On the Structure of the Nephridia of* DINOPHILUS. Quart. Journ. Micr. Sci., vol. 50, 1906, pp. 517–545.

WOODLAND, W.—*A Preliminary Consideration as to the possible Factors concerned in the Production of the various Forms of Spicules.* Quart. Journ. Micr. Sci., vol. 51, 1907, pp. 55–79.

WOODLAND, W.—*Studies in Spicule Formation.* V.—*The Scleroblastic Development of the Spicules in Ophiuroidea and Echinoidea, and in the Genera Antedon and Synapta.* VI.—*The Scleroblastic Development of the Spicules in some Mollusca, and in one Genus of Colonial Ascidians.* Quart. Journ. Micr. Sci., vol. 51, 1907, pp. 31–53.

WOODLAND, W.—*On the Anatomy of* CENTROPHORUS CALCEUS (CREPIDALBUS *Bocage and Capello) Günther.* Proceed. Zool. Soc., London, 1906, pp. 865–886.

Donations and Receipts.

The receipts for the year for the ordinary work of the Association include the grants from His Majesty's Treasury (£1000) and the Worshipful Company of Fishmongers (£400), Special Donations (£625), Annual Subscriptions (£113), Rent of Tables in the Laboratory (£70), Sale of Specimens (£384), Admission to the Tank Room (£136).

Vice-Presidents, Officers, and Council.

The following is the list of gentlemen proposed by the Council for election for the year 1907–8:—

President.

Prof. E. RAY LANKESTER, LL.D., F.R.S.

Vice-Presidents.

The Duke of ABERCORN, K.G., C.B.
The Duke of BEDFORD, K.G.
The Earl of ST. GERMANS.
The Earl of DUCIE, F.R.S.
Lord AVEBURY, F.R.S.
Lord TWEEDMOUTH, P.C.
Lord WALSINGHAM, F.R.S.
The Right Hon. A. J. BALFOUR, M.P., F.R.S.
The Right Hon. JOSEPH CHAMBERLAIN, M.P.
The Right Hon. AUSTEN CHAMBERLAIN, M.P.
Sir EDWARD BIRKBECK, Bart.
A. C. L. GÜNTHER, Esq., F.R.S.
Sir JOHN MURRAY, F.R.S.
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G. L. Alward, Esq.
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J. J. Lister, Esq., F.R.S.
H. R. Mill, Esq., D.Sc.
P. Chalmers Mitchell, Esq., F.R.S.
Prof. D'Arcy W. Thompson, C.B.
R. N. Wolfenden, Esq., M.D.

Chairman of Council.

A. E. Shipley, Esq., F.R.S.

Hon. Treasurer.

J. A. Travers, Esq.

Hon. Secretary.

E. J. Allen, Esq., D.Sc., The Laboratory, Citadel Hill, Plymouth.

The following Governors are also members of the Council:—

G. P. Bidder, Esq., M.A.
Sir Richard B. Martin, Bart. (Prime Warden of the Fishmongers' Company).
E. L. Beckwith, Esq. (Fishmongers' Company).
G. C. Bourne, Esq., D.Sc. (Oxford University).
A. E. Shipley, Esq., F.R.S. (Cambridge University).
Prof. W. A. Herdman, D.Sc., F.R.S. (British Association).

STATEMENT OF
RECEIPTS AND EXPENDITURE.

Dr. *Statement of Receipts and Payments for*

		£	s.	d.	£	s.	d.
To Current Income :—							
H.M. Treasury		1,000	0	0			
Fishmongers' Company		400	0	0			
Annual Subscriptions		113	7	0			
Rent of Tables		70	12	0	1,583	19	0
„ Extraordinary Receipts :—							
G. P. Bidder, Special Donation towards expenses of International Fishery Investigation (see contra).		500	0	0			
Anonymous, Special Donation		100	0	0			
J. J. Lister do.		25	0	0	625	0	0
„ Balance :—							
Loan from Bank		400	0	0			
Less :—							
Cash at Bank, Current Account	69 1 0						
Cash in hand	20 11 4	89	12	4	310	7	8
Note.—This balance is apportioned as follows :—							
General Account, overdrawn		468	19	10			
Less Repairs and Renewals Account in credit		158	12	2			
		£310	7	8			
					£2,519	6	8

This Liability does not include the amount of £100 referred to on the accounts for the year ending 31st May, 1905.

Examined and found correct,

(Signed) N. E. Waterhouse, A.C.A. L. W. Byrne.

R. Norris Wolfenden.

26th June, 1907.

the Year ending 31*st May*, 1907. **Cr.**

	£	s.	d.	£	s.	d.	£	s.	d.
By Balance from last year, being amount due to Bankers ...				171	5	10			
Less Cash in hand				20	4	0	151	1	10
,, Current Expenditure :—									
Salaries and Wages—									
Director				200	0	0			
Naturalist (International Fishery Investigations) ...				250	0	0			
Director's Assistant				150	0	0			
Wages				658	5	3	1,258	5	3
Travelling Expenses							89	17	7
Library							82	4	0
Journal				75	5	9			
Less Sales of Journal				16	10	5	58	15	4
Buildings and Public Tank Room—									
Gas, Water, and Coal				95	10	5			
Stocking Tanks, Feeding, etc.				19	3	5			
Maintenance and Renewals				102	10	4			
Rent of Land, Rates, Taxes, and Insurance				17	5	9			
				234	9	11			
Less Admissions to Tank Room				136	7	11	98	2	0
Laboratory, Boats, and Sundry Expenses—									
Stationery, Office Expenses, Printing, etc.				168	1	5			
Glass, Chemicals, and Apparatus	£182	16	4						
Less Sales	74	10	9	108	5	7			
Purchase of Specimens				51	15	2			
Maintenance and Renewal of Boats, Nets, Gear, etc.	£277	6	7						
Less Sales	28	15	6	248	11	1			
Coal and Water for Steamer				138	2	5			
				714	15	8			
Less Sales of Specimens, etc. (including £50 from International Investigations Commission for use of s.s. *Oithona*)				434	12	3	280	3	5
Bank Interest							0	17	3
,, Extraordinary Expenditure :—									
Contribution towards the expenses of the International Fishery Investigations							500	0	0
							£2,519	6	8

Notes on a Fishing Voyage to the Barents Sea in August, 1907.

By

George T. Atkinson,

Assistant at the Lowestoft Laboratory.

With Plate IV and three figures in the Text.

CONTENTS.

CHIEFLY with the object of obtaining material from which comparisons of an intact plaice population with that at present existing in the North Sea might be made, I undertook, in August, 1907, a voyage in a commercial steam trawler to the new fishing grounds in the "White Sea."*

As this area was only exploited commercially by trawlers for the first time in 1905, an exceptional opportunity was afforded for the study of an accumulated stock of plaice unaffected by the influence of man.

To Mr. F. O. Hellyer, who kindly arranged the voyage for me in the s.s. *Roman*, of the Imperial Steam Fishing Company, Hull, and to Captain W. Leighton, through whose co-operation I was enabled to measure and examine over four thousand plaice, my heartiest thanks

* Generally so mis-named. Very little trawling has taken place within the White Sea proper, nor has it proved profitable.

are due. I am also indebted to my friend, Mr. A. E. Jones, who accompanied me and recorded the various measurements. During the collation of my material and the preparation of this memoir, I have received much valuable assistance and advice from my colleagues at Lowestoft, particularly from Drs. Wallace, Garstang, and Allen.

Owing to the keen struggle to make and keep the "White Sea" fishing a commercial success, it was naturally stipulated that the actual position of the fishing grounds should not be revealed. This from the immediate scientific point of view is immaterial, nor was it the object of the investigation.

Depths, however, are of importance in the distribution of plaice, and their insertion entails no breach of trust, as the latest Admiralty charts afford no clue to the position of the fishing bank visited. Doubtless in the course of time the fishing in the area will be generally understood, but by that time the pioneer fishermen of Hull will have reaped the rich reward of their discoveries, and the knowledge gained will continue to stand them in good stead.

I propose here to deal with the notes made on the various fishes met with during the voyage, but before doing so will recall briefly the general conditions which are found throughout the year in the Barents Sea as far as they are at present known.*

The sea is at its coldest in June. From this time an inflow of Atlantic water commences, and continues till November, bestowing a considerable increase of temperature on the whole area. After November the influence of the Arctic water gradually predominates. It has been pointed out by Knipowitsch that the fisheries of the Barents Sea are dependent on this annual flood of warm Atlantic water.

The coming of the most important fishes with this flood, and their subsequent departure when Arctic conditions again prevail, have been studied by the Russian investigators by means of fishing experiments. By these means it has been found that quantities of fish can be obtained in the neighbourhood of the different branches of the North Cape Current at the times when there is no fishery worthy of mention on the usual fishing grounds along the Murman coast. To cite one example†: from May 15–17th, 1898, quantities of haddock, catfish, halibut, black halibut, cod, Norway haddocks, tusk, and other fish were

* L. Breitfuss. *Ozeanographische Studien über das Barents Meer. Petermanns Mitteilungen*, II, 1904.

N. Knipowitsch. *Expedition für wissenschaftlich-praktische Untersuchungen an der Murman-Küste*, I. Cf. *Rapports et Procès-verbaux.* Appendix A, Vol. iii, 1905.

† N. Knipowitsch. *Expedition für wissenschaftlich-praktische Untersuchungen an der Murman-Küste*, I, p. 594.

caught by means of long-lines in Lat. 71° 14′ N., Long. 32° 46′ E., a position in the southernmost branch of the constant North Cape Current.

At this time the fishing on the Murman coast was of no importance, and the conviction of the fishermen was that no fish would be found out in the open sea.

Knipowitsch records that in March and April the Murman coast is very deficient in fish, though quantities can be met with as a rule more to the west (north of Finmark, etc.). Then the eastward migration commences, the chief shoals still being found in the neighbourhood of the well-marked warm stream. As summer approaches, they draw near the coast, and the population of the open sea decreases.

Late in summer the fish still press on to the east, towards the neighbourhood of Cape Kanin. Late in autumn the return migration from the coast commences, though many fish can remain till mid-winter* off the Murman coast.

Marked differences have been observed in the fauna as the bottom temperature rises above the freezing point; it is very rare to find the valuable food-fishes present in water with a temperature below freezing point. Bearing this in mind, it is probable that the use of a satisfactory deep sea thermometer would greatly assist the efforts of our own fishermen in these regions. As they first work in this sea in June and July,† when the influence of the Atlantic flood is commencing to extend, a thermometer might prove as useful a guide as the lead. Though it cannot be claimed that such an instrument would show where fish are to be caught, futile trawling in the unproductive, ice-cold Arctic water, which undoubtedly has taken place, might be avoided.

By means of a simple reversing thermometer of his own design, to be worked on the ordinary leadline, kindly supplied me by Mr. D. J. Matthews, of the Plymouth Laboratory, I was able to determine on several occasions that the bottom temperature on the bank where the plaice were chiefly taken was 34° F., or two degrees above freezing point. The surface temperature at the the same times varied from 45°–48° F. In similar depths (34–36 fathoms) in the North Sea the difference in top and bottom temperatures would only be slight.

An English trawler in June, working in suitable depths some distance to the eastward of the fishing ground now under consideration, found an almost entire absence of plaice, and the icy coldness of

* The winter in respect of the land, not sea.—G. T. A.

† The tendency has been to make an earlier start each year. In 1907 the first trawler left Hull on May 1st.

the water was remarked on; the region had then eventually to be abandoned, and the fishing voyage concluded at Iceland. In my notes on the plaice the influence of temperature on the movements of this species in other regions will be further indicated.

The Plaice (*Pleuronectes platessa*).

This was by far the most abundant species met with, and is of course the special object of the trawlers' exploitation of the region.

Throughout the greater part of this voyage on the *Roman*, samples of the catch were measured and examined.

Methods of Obtaining and Measuring Samples.

The method of obtaining and working through the samples was as follows: As the contents of the trawl lay upon the deck, the crew proceeded to gut the plaice and throw them one by one into the "pound" on the side of the deck opposite to which the trawl had been hauled, where they were eventually washed before being put below.

Thus, by getting one or more of the men to put their gutted fish as they picked them unselected from the deck into baskets, and by taking as many baskets as it was possible to dispose of without interfering with the regular routine of the ship, good samples could be obtained.

The gutting process consists of making an incision into the body cavity, through which the viscera, with the exception of the reproductive organs, are extracted. Thus it was comparatively easy to make an examination of the maturity of each individual fish.

The international method of measurement was adopted (e.g. 39–39·9 cm., recorded as 39 cm.), and the operation was carried out on a portable measuring board, on the open deck in fine weather and under the "whaleback," or roofed-in bow deck, when it was rough.

On six occasions the whole catch of plaice was measured and examined. The close agreement of the average sizes (p. 76) then obtained, with those of smaller samples at other stations in the vicinity, confirms the confidence in the value of the smaller samples.

As each measurement was made and recorded the sex of the fish was noted, together with the maturity. From these records (Table I) it will be seen that the lengths of the smallest mature fishes were 24 and 35 cm. for male and female respectively, and the corresponding largest immature 41 and 45 cm. The average size of the mature males is 40·9 cm., and of the mature females 48·3 cm.

The lengths of 113 fish (65 ♂, 48 ♀) have been excluded from all consideration, as in each of these cases the tail had been more or less

damaged, sometimes half, and even the whole, of it being missing, and the record was only kept to show the great frequency with which this damaged condition occurred. I am strongly inclined to agree with the fishermen, who noticed this feature in the previous year, and to attribute it to the depredations of the Greenland shark (*Laemargus microcephalus*), which without a doubt includes the plaice in its diet (see p. 97). If this is the case, the fact that nearly 2½ per cent of the fish in my samples were in this condition is significant, and shows that

TABLE I.—*Showing the actual length frequencies of plaice measured on board the s.s. "Roman" in the Barents Sea, August,* 1907 *; classified according to maturity* :—

MALES.

Length cm.	Maturity. Immature.	Mature.	?	Total.
24	–	1	–	1
25	–	1	–	1
26	1	–	1	2
27	1	1	–	2
28	–	1	–	1
29	–	2	3	5
30	1	2	3	6
31	4	4	3	11
32	2	12	3	17
33	3	11	5	19
34	4	18	4	26
35	2	30	7	39
36	–	79	–	79
37	3	129	3	135
38	1	176	1	178
39	–	202	1	203
40	–	235	1	236
41	1	294	1	296
42	–	254	1	255
43	–	195	–	195
44	–	159	–	159
45	–	116	–	116
46	–	72	1	73
47	–	41	1	42
48	–	19	1	20
49	–	13	1	14
50	–	4	–	4
51	–	2	2	4
52	–	1	–	1
53	–	2	1	3
54	–	–	–	–
55	–	1	–	1
56	–	–	–	–
57	–	1	1	2
Totals	23	2078	45	2146

FEMALES.

Length. cm.	Maturity. Immature.	Mature.	?	Total.
24	1	–	–	1
25	–	–	–	–
26	1	–	–	1
27	3	–	–	3
28	2	–	–	2
29	1	–	–	1
30	5	–	–	5
31	9	–	1	10
32	8	–	–	8
33	12	–	1	13
34	15	–	2	17
35	18	1	2	21
36	16	–	5	21
37	18	1	14	33
38	11	4	17	32
39	19	12	19	50
40	13	26	28	67
41	16	51	37	104
42	5	77	31	113
43	7	87	23	117
44	1	109	16	126
45	3	168	18	189
46	–	168	10	178
47	–	186	3	189
48	–	178	5	183
49	–	175	4	179
50	–	140	1	141
51	–	132	2	134
52	–	104	1	105
53	–	86	–	86
54	–	60	–	60
55	–	62	–	62
56	–	32	–	32
57	–	28	–	28
58	–	19	–	19
59	–	7	–	7
60	–	7	–	7
61	–	5	–	5
62	–	6	–	6
63	–	3	–	3
64	–	2	–	2
65	–	4	–	4
73	–	1	–	1
Totals	184	1941	240	2365

in this region at least the plaice lives in the presence of a serious natural enemy (or enemies, for though the food of the seals in the Barents Sea has not yet been sufficiently studied, the possibility of their preying upon plaice is by no means precluded).

It may perhaps seem possible that, owing to the novelty of this phenomenon, the fishermen would be inclined specially to select these damaged fish for my benefit, thus exaggerating their occurrence. I am confident that this is not the case, as the men were not even aware that these fish were being in any way regarded.

The Composition of the Catch.

The length frequencies of 2146 females and 2365 males, representing over three tons of fish, are shown in Table I above, each sex being subdivided, according to maturity. The measurements, arranged in 2 cm. groups, are further displayed in diagrams (pages 78 and 79).

Care was taken to secure as fair a sample as possible of each catch dealt with. That this object was attained appears evident from the slight variations in the average sizes at the twenty-nine stations. For the males, of which the averages vary between the narrow limits of 40·4 cm. and 41·9 cm., a total average size of 40·7 cm. is obtained; in the case of the females, as might be expected, a greater range in the average sizes occurs: 45·3 cm.–48·9 c.m., with one exception, 50·5 cm. (in the smallest sample taken). The total average size of 2365 female fish is 46·7 cm.

The population consisted almost entirely of large mature fish, the total range of size being for males 24 cm. to 57 cm., and for females 24 cm. to 73 cm.

In Table II below the measurements for each sex are summarized in 5 cm. groups, the percentage of males in each being also presented.

Table II.—*Showing the measurements of Barents Sea plaice summarized in 5 cm. groups, the percentage of males in each group being presented below:—*

Cm.	<30	30–34	35–39	40–44	45–49	50–54	55–59	60+	Total.
♂ . . .	12	79	634	1141	265	12	3	–	2146
♀ . . .	8	53	157	527	918	526	148	28	2365
Totals	20	132	791	1668	1183	538	151	28	4511
% of Males .	60	60	80	68	22	2	2	0	47

The striking feature of this table is the great proportion of males in each group up to 40–44 cm., and the subsequent rapid decrease.

The male plaice is generally recognised as being a constitutionally smaller fish than the female, and would not be expected to attain to

the same length, but at the same time the rapid decrease after 44 cm., and virtual disappearance after 49 cm., is surprising.

In this recently spawned shoal the usual earlier maturity of the sex* would account for the great numbers of males in the smaller groups; for instance, in the 35–39 cm. group 96 per cent of the males were mature, in contrast to only 11 per cent of the females. To only a small extent would this account for the high percentage of males being maintained in the next group, as only 8 per cent of the females now remain immature. We must look for some other explanation, which seems to me to lie in the probable infinitesimal annual growth which the males now undergo. The fishes of this sex are now some 10 or more centimetres above the size I have estimated for first maturity, after which stage in life considerable retardation of growth takes place.† It is probable, therefore, that in these slow growing plaice (see p. 84) of the Barents Sea many year groups are comprised in this arbitrary 40–44 cm. group.

It is probable, too, that the rapid diminution in numbers and final disappearance of males in the succeeding groups is accentuated by an earlier mortality of the sex here, as in the North Sea.‡ Looking at the curves of length frequencies it will be seen that the curve for the males does fall more rapidly from its mode or maximum height (at 41 cm.) than does that for the females from its mode (at 47 cm.).

The variation in the proportion of the sexes at individual stations and groups of stations, as possibly giving a clue to migrations, is dealt with later (p. 87).

The curves of length frequencies (Figs. 1 and 2) in the case of both sexes, display remarkable regularity, representing an absolutely intact stock of *mature* plaice, such as is to be found in no other region of the world at present fished. A series of annual observations, tracing the inevitable reduction of this stock by the influence of man, and a contemporary study of this fishery's statistics in their modern improved form, will throw interesting and valuable light on the changing aspects of a plaice fishery. Icelandic waters cannot now afford similar opportunities, for in the comparatively few years this region has been exploited for plaice a marked reduction of the original stock is observed by the fishermen to have occurred.

* Fulton. *Twentieth Annual Report Fishery Board for Scotland*, Part III, pp. 354–60 (1902).

Wallace. *Preliminary Investigations on the Age and Growth-Rate of Plaice.* North Sea Investigation Committee, Report 2. Southern Area, 1902–3. Cd. 2670 (1905), pp. 218, etc.

† Wallace. *Report on the Age and Growth-Rate of Plaice in the Southern North Sea.* North Sea Investigation Committee. Second Report (Southern Area), 1904–5, Part I, p. 33.

‡ Wallace. *Loc. cit.*, p. 34.

MALES.

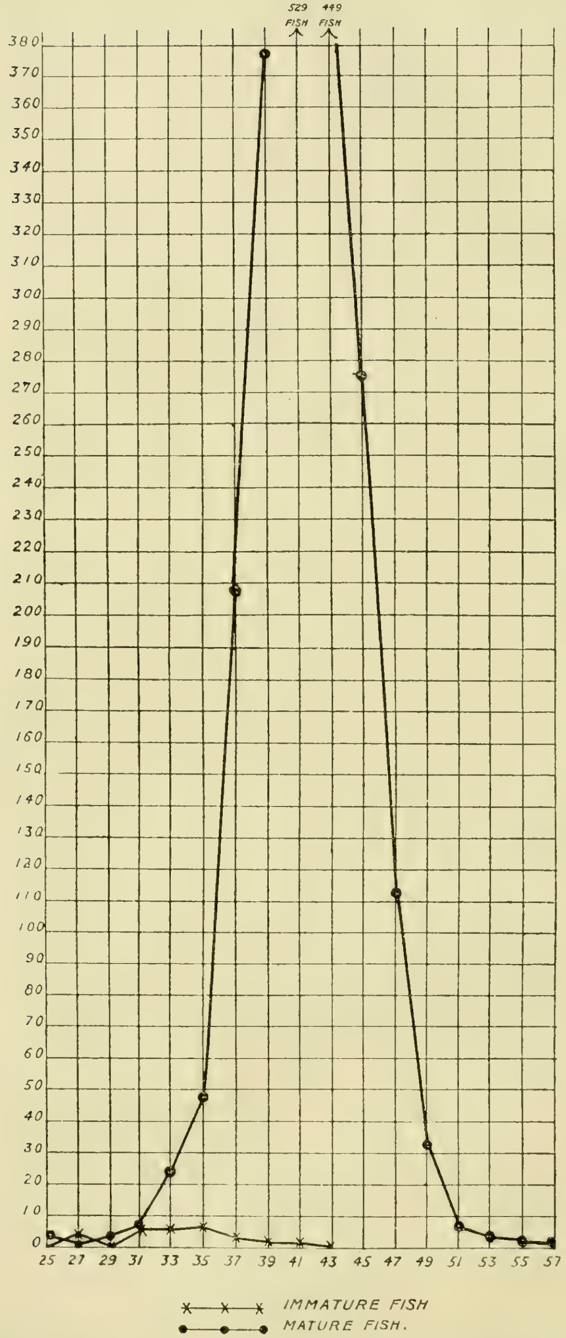


FIG. 1.—Showing the length frequencies in 2 cm. groups of 2,101 male plaice. Barents Sea, August, 1907.

FEMALES.

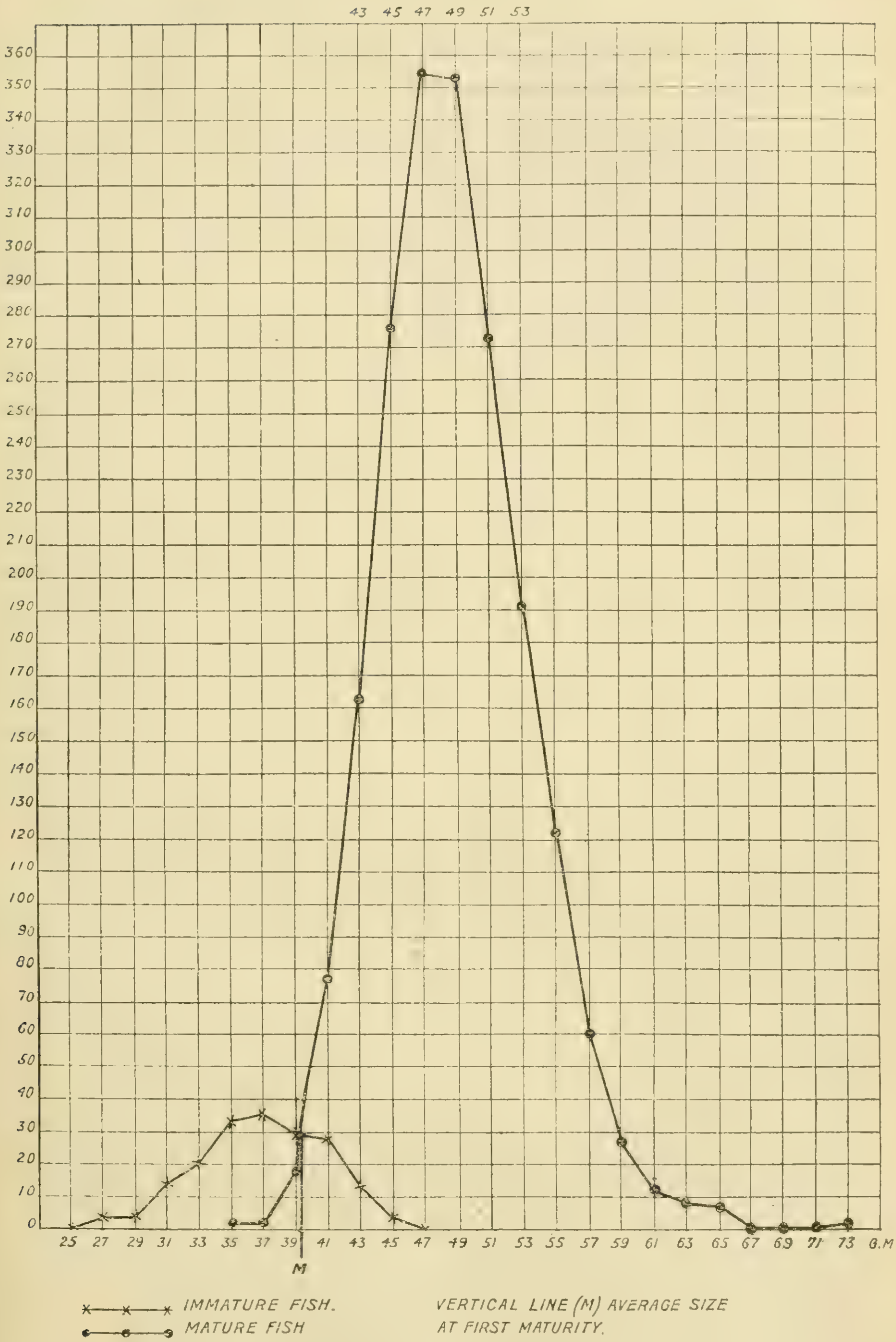


FIG. 2.—Showing the length frequencies in 2 cm. groups of 2,125 female plaice. Barents Sea, August, 1907.

Maturity Examination.

Owing to the method of gutting and the recent completion of the spawning season, examination of maturity was greatly facilitated.

Before each fish was measured, the sex was determined by an inspection of the reproductive organs simultaneously with an observation of the condition, whether immature, mature (i.e. spent), or doubtful. The stage "spent" could generally be readily distinguished in the females, as it was possible to press out greater or less quantities of dead eggs from the ovary. The characteristic flaccid appearance of this organ afforded an additional criterion.

Quite distinct were the taut, translucent ovaries of the immature specimens.

Milt still flowed freely from the majority of the males, and definitely immature fish were of very rare occurrence throughout the voyage, as is also the case in the *spawning* shoals of the North Sea. These were to be distinguished by the testis appearing a mere thin band, at this time contrasting with the condition of the recently spawned individuals.

However, in order that errors of observation might be avoided, a special record was kept of every fish of which the condition was in any way open to doubt. Into this class were placed those fish of either sex which on further trial failed to show the presence of sexual products, and yet seemed to differ from those which were definitely immature.

Facilities were not available, nor is the deck of a trawler an ideal spot for making the minutest examinations, but it is evident that the main results are not seriously affected, as the size at which the maximum number of measurements of doubtful fish occurs, in the case of the females, will be seen to lie in close proximity to the determined average size at first maturity. In the measurements of the males, the maximum lies where the size at first maturity would appear to be forecasted.

The condition of eight males* occurring in the samples was remarkable from the fact that, although the fish were large, the gonads were in an undeveloped condition, and I am not aware that a similar feature has been recorded before. The majority of the lengths, viz. 40, 41, 47, 48, 51, 51, 53 and 57 cm., obviously render the probability of immaturity very remote, and yet to judge by all appearances, these fish had certainly not been in a spawning condition in this year. In

* Two more occurred in the earliest samples, but I rejected them, thinking that the apparent absence of reproductive organs was due to accidental removal in gutting.

one fish, 57 cm., the testis, about 2 mm. wide, was such as is found in the immature condition, but the measurement is the largest in the records for the sex. As regards the other seven fishes, no definite testis could be traced.

Whether this phenomenon was due to the lifelong sterility of the individuals, or to the fact that sterility had supervened on account of the great age to which they must have survived, is an interesting biological question which must for the present remain open.

Having made an extensive examination of spawning plaice in the southern parts of the North Sea in the spawning season (January–February) this year (1907), I received the distinct impression that the quantity of spermatic fluid and unextruded dead ova was far greater in the Barents Sea fish than in those of the southern region. It would be interesting if investigation should prove this to be actually the case.

No females actually spawning or about to spawn were found, and it will be seen from the summary of measurements that the number of immature fish of both sexes was very small, particularly in the case of the males.

It is interesting to find that the greatest number of immature occurred in the haul across the shoalest part of the bank (26 fms.) at the end of the first day's fishing. The catch then consisted of eighteen baskets of plaice, of which four were measured. These contained 183 fish (73 males, 110 females). Of the males, 7, or 9½ per cent, were definitely immature; and 11, or 15 per cent, recorded as doubtful. Of the females, 24, or 22 per cent, were immature; and 5, or 4½ per cent, doubtful. Thus, of the fish in this sample, 18 males, or 25 per cent, and 29 females, or 26 per cent were possibly immature. Taking all the other stations, and classing the immature and doubtful fish together in the same way as "possibly immature," I find only about 3 per cent of the males, and 16 per cent of the females would fall into that category.

As a result of the international investigations in progress, we know that the same phenomenon, viz. an excess in the proportions of immature females compared with that of immature males, also obtains on the central grounds of the North Sea at a similar period.

The length of the smallest mature male was 24 cm., and of the smallest mature female, 35 cm. The largest immature female was 45 cm. The largest immature male was recorded as 41 cm., but this record is rendered open to doubt by the curious condition of the eight males recorded above. The average size of the mature males is 40·9 cm., and of the mature females, 48·3 cm.

The Average Size at First Maturity.

The average size at first maturity, that is to say, the size at which equal numbers of mature and immature fish occur, I find to be about 40 cm. (see diagram, page 79), in the case of the females.

In regard to the males, owing to the virtual absence of immature individuals, this size cannot be determined. The indications, however, from the material available, point to this size being not far remote from 31 cm.

These sizes correspond closely with those Dr. Wallace kindly informs me he has determined from 895 females and 561 males for the central grounds of the North Sea (Dogger, Flamborough Off Grounds, Clay Deep, etc.), viz., 40 cm. for females and 31 cm. for males. The correspondence is remarkable, and would hardly seem a mere coincidence. It is evident, however, that the plaice of the Barents Sea mature at a much later age (p. 85).

Age.

The age investigation presents many difficulties. It is evident that the rate of growth is extremely slow, and this not only renders the distinction of year groups impossible by a study of the length frequencies (Petersen method), but it is also reflected in the otoliths, on which the annual rings are so narrow and crowded together that only in the case of the smallest fishes found has it been possible to estimate the age with a degree of certainty.

I made a small collection of otoliths on board the *Roman*, and although this material is quite insufficient for obtaining an estimate of the rate of growth, it can be seen that this is exceedingly slow, even during the years before maturity is attained.

A noticeable feature of these otoliths is the contrast of the comparative width of the white and dark rings, the latter being exceedingly narrow.

The physical conditions which apparently regulate the deposition of these respective rings have been studied in the case of plaice from the Baltic and North Seas.

Various investigators* have found that the white ring first shows itself in spring, when the temperature of the water commences to rise and the fish to feed. In late summer and into the autumn (the period

* Reibisch. *Ueber die Eizahl bei Pleuronectes platessa und die Altersbestimmung dieser Form aus den Otolithen.* Wiss. Meeres. Abt., Kiel, N. F. Bd. 4, 1899.

Maier. *Beiträge zur Altersbestimmung der Fische ;* Arb. d. wissen. Komm. f.d. Intern. Meeres. No. 5. Bd. viii., 1907.

Wallace. *Loc. cit.*

of warmest water and most rapid growth in the North Sea) the dark ring is formed. In winter the growth of the otolith, as of the fish, ceases.

Immermann* has shown that these rings on the otoliths of the plaice are purely optical effects, explicable by the regular changes in the life conditions of the fish.

Avoiding technicalities, the reason for the occurrence of apparent white and dark rings is as follows: The whole otolith is composed of layers of chalk substance deposited regularly as the growth of the fish is in progress. Restrained growth, as when cold water conditions prevail, has the effect of crowding together these layers. As the temperature rises, and the growth rate of the fish increases, so must that of the otolith, and thus is effected a wider expansion of the layers of chalk substance. The optical effect of this is that the crowded rings, not permitting the passage of light, appear white, whilst the expanded translucent layers appear dark by contrast.

The reason for the narrowness of the dark ring, and the comparative great width of the white ring in the otolith of the Barents Sea plaice, is thus afforded. For the greater part of their annual growth-period these fish are subjected to very low temperature (at the time of my visit the bottom temperature was only two degrees Fahrenheit above the freezing point), so that for only a short period would rapid growth appear to take place, and it is not unlikely that this period coincides with the culmination of the Atlantic flood.

As has been pointed out before (p. 72), this expansion of Atlantic water is in progress in the month of August; in other words, biological spring has commenced. Correlated with this physical phenomenon the otoliths of the plaice *show the commencement of a white ring at the edge.* In the North Sea by this time, according to investigations (Wallace, Maier, etc.), the dark ring has commenced. Thus in the two regions of the ocean, many hundreds of miles apart, it can be seen on the otoliths of the plaice that biological spring in the one region coincides with midsummer in the other, as we know to be the case from hydrographic observations referred to above.

For suggestions and help in the investigation of the small collection of otoliths, I am greatly indebted to Dr. Wallace, who also kindly undertook an independent investigation of a number. Our two results were in close agreement, the chief discrepancies being in the case of otoliths on which certain of the rings appeared to split in a doubtful manner.

* *Beiträge zur Altersbestimmung der Fische II. Die innere Struktur der Schollen Otolithen.* Arb. d. wissen. Kom. f.d. Intern. Meeres. No. 6. Bd. vi., 1907.

In Table III are shown the ages of certain individual fishes, reckoning that, as in the North Sea, one white ring is deposited annually, and that each fish had recently completed the number of years specified. In the case of the larger (older) fishes, the outer rings are so crowded together that accurate counting would seem impossible.

I have, however, included a few examples of these, estimating the age at *not less than a* certain number of years, as shown by the number of distinct white rings.

If fishes of either sex are not less than ten years old when 40 cm. in length, to what age must a male of 57 cm. or a female 73 cm. in

TABLE III.—*Showing the age of certain individual plaice from the Barents Sea, August,* 1907, *estimated according to the number of white rings shown on the otoliths*:—

	MALES.			FEMALES.	
	Number of White Rings.			Number of White Rings.	
Length cm.	Immature.	Mature.	Maturity Doubtful.	Immature.	Mature.
24 . .	–	–	–	6	–
26 . .	–	–	6	–	–
27 . .	5	9	–	6	–
	–	–	–	5	–
	–	–	–	6	–
28 . .	–	–	–	10	–
	–	–	–	6	–
29 . .	6	9	–	6	–
	–	–	–	6	–
30 . .	–	–	10[1]	9	–
	–	–	–	9	–
	–	–	–	10	–
31 . .	8	–	–	7	–
	7	–	–	8	–
	–	–	–	8	–
	–	–	–	9	–
32 . .	9	8	–	9	–
	–	–	–	9	–
	–	–	–	9	–
33 . .	–	8	–	10	–
34 . .	–	–	–	not ∠ 9	–
35 . .	–	–	–	9	–
37 . .	–	not ∠ 11	–	–	–
39 . .	–	not ∠ 11	–	–	–
	–	not ∠ 15	–	–	–
	–	11	–	–	–
40 . .	–	not ∠ 11	–	–	–
	–	not ∠ 10	–	–	–
41 . .	–	11	–	not ∠ 12	not ∠ 12
	–	not ∠ 13	–	–	–
	–	11	–	–	–
	–	not ∠ 10	–	–	–
42 . .	–	not ∠ 11	not ∠ 11	–	–
43 . .	–	not ∠ 15	–	–	–
44 . .	–	–	–	–	not ∠ 12
45 . .	–	not ∠ 12	–	–	–
	–	not ∠ 12	–	–	–
46 . .	–	not ∠ 16[2]	–	–	not ∠ 20
50 . .	–	–	–	–	not ∠ 21
54 . .	–	–	–	–	not ∠ 18

[1] Probably 10. [2] Probably 17.

length have survived, considering that each year the growth becomes less and less!

Although the material in Table III cannot be regarded as satisfactory, it shows plainly how slow the rate of growth must be, and would seem indicative of the direction future plaice investigations should take in this inhospitable region.

In connection with the majority of these specimens (Table III), the possibility presents itself that they may be actually amongst the best grown fishes of their respective year groups. That plaice in the North Sea are larger for their age the further they are caught from the coastal grounds has been very clearly shown by Wallace in a recent paper (*op. cit*), so it seems possible, if not probable, that a similar state of things obtains in the off-shore grounds of the Barents Sea.

The youngest plaice of either sex amongst those examined had apparently already completed five years, but this would seem quite exceptional. In addition to the slow rate of growth, the evident late age at which maturity is attained is striking.

Amongst these few fish examined for age, no male less than eight years (32 cm.), and no female less than twelve years old (41 cm.) was found to be mature, though younger mature specimens must have *occasionally* been present in the catch (see Table I). In the North Sea few males are found to survive to eight years.

If the plaice in the Barents Sea have really to live through some eight or nine years before they attain the size at which they reproduce their species, the question occurs to us, "How long will the present stock, accumulated through many years, hold out in sufficient abundance to make this long, expensive voyage of three to four thousand miles down to the Arctic Ocean profitable to our trawlers?"

Migrations.

Speaking in a general way, the migrations of mature fish seem to be determined by the search for food, or to be in connection with the reproduction of the species. Currents, temperature, and such local factors as a general exodus from shoal to deeper water in stormy weather, are amongst other causes of fish movements, but all have more or less direct bearing on one of the main stimuli.

Although conclusions as to migrations in the Barents Sea would be impossible from the material collected on the voyage of the *Roman*, nevertheless every fact in my possession points to a general movement of this mature plaice population from deeper and here probably warmer water, after spawning has taken place, on to the banks to the eastward, apparently in search of food.

That rich supplies of molluscs were available, was evident from the frequent occurrence of living specimens in the trawl; the masses of crushed shells in the stomachs of the plaice and catfish; and, perhaps most important of all, the fine, plump condition of the plaice when first caught. This is a striking contrast to the condition met with a few years ago at Iceland, and reported of the earliest trawling times on the Dogger Bank.

How sensitive some fishes are to external conditions, when about to spawn, has been pointed out by Schmidt.* The same investigator has found more recently† that plaice marked on the north and east coasts of Iceland, migrate from their cold surroundings towards the warm Atlantic water, when preparing for reproduction.

As further contributing to our knowledge on this problem, I find that among the Lowestoft fishermen, whose fishing in January and February is almost entirely confined to the spawning plaice of the southernmost North Sea, it is common knowledge that in a severe, cold winter, plaice always set in more abundantly, and remain longer, in the deep channels of this region, than is the case when the winter is mild. Hydrographic observations have shown that the water here is of Channel origin, and has a higher temperature at this period than any other part of the southern North Sea.

From the evidence I shall present below, it will be seen that the spawning plaice of the Barents Sea probably seek to the west the more congenial surroundings which their condition demands.

The Russian hydrographers‡ have pointed out how the ramifications of the North Cape current follow well-defined channels along the sea bottom towards the east, and we may perhaps justifiably surmise that the influence extends to the deep water west of the bank on which the present investigations were carried out.

At any rate, it is the experience of our fishermen that the plaice are found further to the west, and in denser shoals, when they first visit these grounds in June and July, than later in the season. I should estimate, from the condition of the fish taken by the *Roman* in August, that this year the spawning season terminated in July.

An analysis of the *Roman's* hauls of the first two days, relative to their respective positions and depths, reveals features which bear comparison with North Sea grounds at a similar period, viz., just after

* JOHS SCHMIDT. "Contributions to the Life History of the Eel," (Anguilla vulgaris. Turt.), *Rapports et Procès-Verbaux*, V, p. 234, *et seq.*, 1906.

† *Marking Experiments on Plaice and Cod in Icelandic Waters.* Meddel. fra Komm. f. Havunders., Serie Fiskeri. Bind ii, No. 6, 1907.

‡ *Rapports et Procès-Verbaux*, Vol. iii, 1905. Appendix A, pp. 3 and 4.

spawning has taken place. This is in regard to the proportions of the sexes.

Recent investigations* have shown that a high percentage of males is characteristic of the catches in areas where plaice are spawning, or have recently spawned. To gain additional knowledge on this point, I made, in the first days of February this year (1907), a voyage in the Lowestoft smack *Rosebud*, and measured all the plaice caught, 2631 fish, of these no fewer than 85 per cent being males. The spawning season had then about half expired.

TABLE IV.—*Showing analysis of the total catch of plaice made by the Lowestoft sailing-trawler "Rosebud," January 31st to February 5th,* 1907. *Eastern Deep Water:—*

Cm.	<20	20–24	25–29	30–34	35–39	40–44	45–49	50–54	>55	Total.
♂	202	648	555	505	257	50	9	–	–	2226
♀	1	38	148	108	48	33	23	4	2	405
Totals	203	686	703	613	305	83	32	4	2	2631
Percentage of Males	99·5	95	79	82	84	60	28	0	0	85
Spent Females .	–	7	18	26	24	18	7	2	1	103
Immature Females .	1	26	115	64	6	–	–	–	–	212

The early hauls of the *Roman*, referred to just above, were, roughly speaking, in a series—starting from the deep water to the west of the bank, extending over the same, and dropping again into deep water to the east of it.

Three hauls were made up the western slope at depths of 55, 40, and 38 fathoms. The complete catch of two of these hauls, and a greater part of the third, was measured, and the condition of the reproductive organs examined, the numbers showing that males greatly predominated here.

Out of the 294 fish comprising these samples, 179, or 61 per cent, were males; the first haul, indeed, in 55 fathoms, resulted in a catch of 42 fish, of which 33, or 79 per cent, were males.

Crossing the bank with water as shallow as 26 fathoms, measurements of two hauls were made, these samples amounting to 288 fish. The males now only numbered 123, or 43 per cent.

In three hauls down the eastern slope, the water deepening to 49 fathoms and shoaling again to 40, and eventually to 37 fathoms, an eighth, nearly half, and, on the third occasion, the whole of the catch was measured.

A complete reversal in the proportion of the sexes, as compared with the west side, had now taken place. Out of 319 fish dealt with, only 115, or 36 per cent, were males.

After the last haul of this batch, the vessel steamed westward on to

* *Rapports et Procès-Verbaux.* Vol. vii, 1907. Comm. B., p. 20.

the body of the bank, and fish were eventually found in satisfactory quantities. The remaining 21 hauls, from which fish were measured, give 48 per cent of males.

It is evident that this unmistakeable change in the proportions of the sexes from west to east is not without significance, and when we consider that a great preponderance of males is characteristic of spawning areas in the North Sea during, and immediately after the spawning season, it would seem that we have a clue to where these plaice had spawned in the Barents Sea.

Evidence of a probable abundance of plaice some little time previously in the deep water to the west of the bank, was accidentally afforded in the following manner: When first approaching the intended fishing grounds, a trawler's fishing buoy was found anchored in 55 fathoms. No vessel was in sight, and it had been in the water some little time, evidently having been lost sight of in one of the frequent fogs. A trial haul of nearly two hours gave the result previously mentioned, viz., 42 plaice, 33 of which were males.

Now the experienced skippers who make this long voyage to the Arctic Ocean would only be likely to employ a buoy for one of two purposes—to mark either a rough ground, or a shoal of fish. In the latter case plaice would be the species, for in the present limited scope of the fishery this is the only species specially sought after in this region.

No rough ground was encountered in the haul taken, so the probability is that when the buoy was put down quantities of plaice were to be had in the vicinity. It was not until nearly two days later, after searching to the eastward and then returning to the body of the bank, that the *Roman* fell in with sufficient quantities of plaice to warrant the use of a fishing buoy.*

The rapidity with which an accumulation of plaice can under certain conditions disappear from a given spot, is a phenomenon well known amongst fishermen.

Thus we have evidence, indirect and admittedly not conclusive, yet from various aspects corroborative of a distinct eastward movement of these plaice subsequent to spawning. Conversely it would appear as if the westward migration, from this bank at least, into deeper water for the purpose of spawning, might be assumed.

* Since the above was written, information has been obtained on this point, which corroborates in each respect the surmises mentioned in the text. From distinguishing marks on the buoy, and through the courtesy of Captain Leighton, it has been possible to discover the Hull skipper who lost it. He states that it was actually on a bank with 52 fathoms, and was lost in a fog of two days' duration towards the end of June. At that time he was catching sixty baskets of plaice for a two hours' haul.

G. T. A., 27.12 07.

Whither the eggs drift, where the larval forms reach the coastal shallows necessary for the development of young plaice, the life history of these, and where they spend the long years before they reach the outer grounds as mature fish, all afford highly interesting subjects for future investigation.

The pioneering trawlers have found that the plaice are smaller near Cape Kanin, as would be expected, but neither here nor in the entrance to the White Sea, has any great quantity of small fish been found. A study of the Admiralty chart reveals the fact that west of Long. 45° E., the water deepens from the coast comparatively rapidly; indeed, no extensive tracts of shallow water overlying a fine sandy bottom such as characterize the small plaice nurseries in the North Sea, are indicated until Long. 53° E. is passed.

Thereafter to the eastward a long, broad area of fine sandy ground extends across the wide mouth of the Pechora River. It is perhaps significant that the glass balls which Norwegian fishermen employ in connection with their fishing gear, have been found at the mouth of this river.* This reminds us of the drift of derelict fish trunks from our fishing fleets in the North Sea, which with other flotsam, find their way on to the beaches of Holland, Germany, and Denmark, as do also the early developing stages of the plaice.

That this class of evidence is not without significance is shown by the results of later scientific experiments with drift bottles,† by which the trend of the surface currents in the North Sea has been determined.

How the Investigation of the Plaice Fishery in the Barents Sea may throw Light upon the Condition of that Fishery in the North Sea.

It is now desirable to see if from this mass of material from a virgin fishing ground, we can gain any light upon the condition of the plaice fishery in any comparable area of the North Sea.

It must at the outset be recognized that many conditions of life must differ vastly, and yet we have aspects from which this fishing bank in the Barents Sea and the central grounds of the North Sea are comparable as regards the plaice populations at present found on each.

We have the sea bottom in both cases deepening from the coast, whence we may take it the small plaice originate. Far out to sea the

* Nansen. *Oceanography of the North Polar Basin*, Part II, p. 263.

† Fulton. "The Currents of the North Sea and their Relation to Fisheries"; Fifteenth Annual Report Fishery Board for Scotland, Part III, 1897.

Garstang. "Report on the Surface Drift of the English Channel and Neighbouring Seas during 1897," *Journ. M. B. A.*, Vol. v.

bottom rises, forming a bank or banks, rich in the food of plaice: in one case the Dogger Bank, in the other, this uncharted bank discovered by the fishermen from Hull, and on which my investigations were made.

Further seawards in both areas, depths are eventually attained which cease to interest the plaice. In this regard, the Barents Sea is more comparable with the North Sea than is Iceland, where the plaice are restricted by the configuration of the sea bottom to a comparatively narrow coastal zone, throughout their lives. Biologically,

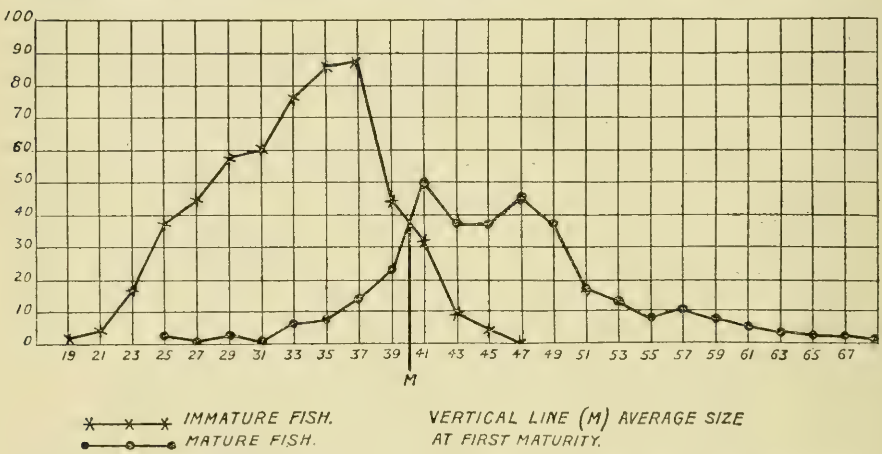


FIG. 3.—Showing the length frequencies of 895 female plaice from the central grounds of the North Sea (Dogger Bank, Clay Deep, etc.).
The ordinates at 19, 21, 23, etc., represent the frequencies in 2 cm. size groups 18–19, 20–21, 22–23 cm. etc.

for both regions, we have this important standpoint from which a comparison can be obtained.

The average size of the females at first maturity was found to be 40 cm. (*approximately*), the same as in the central part of the North Sea.*

Moreover, it is remarkable that out of 2365 and 895 fish from the Barents Sea and the central part of the North Sea respectively, the size of the largest fishes definitely determined as immature should be 45 cm. (Cf. Wallace, Fig. 3).

In order to compare the populations from this standpoint, I have constructed curves of the actual length frequencies of mature and immature female fishes in the two regions (Figs. 2 and 3, pp. 79, 90).

For the rich material from which that for the central North Sea is

* FULTON. 20th, 22nd, and 24th Ann. Report. Fishery Board for Scotland.
HOLT. *Journ. M. B. A.*, Vol. ii.
KYLE. 18th Ann. Report. Fishery Board for Scotland.
WALLACE, *op. cit.*

constructed, I am indebted to Dr. Wallace, who has made the determination of the maturity of 895 female fish on the fishing grounds of the Dogger Bank, Clay Deep, and off Flamborough Head.

In this curve for the central North Sea we find that the immature females, commencing at 18–19 cm., attain their greatest frequency at 36–37 cm., and ultimately disappear after 45 cm. The smallest mature female occurs at 25 cm., with the actual greatest frequency at 40–41 cm. This curve, however, representing the mature fish, rises again at 46–47 cm., so that it seems that its real mode lies between these groups. The largest fish in this collection was 66 cm. long.

In the curve for the Barents Sea (Fig. 2), the smallest immature female was at 24 cm., and then, as in the central part of the North Sea, the greatest frequency occurs at 36–37 cm., and the largest immature specimen at 45 cm. The smallest mature female was found to be 35 cm. in length, and the greatest frequency occurs at 46–47 cm. (thus coinciding with the second mode in the curve for the mature North Sea females, Fig. 3). The largest specimen had a length of 73 cm.

The size at which the numbers of immature and mature are equal (the average size at first maturity), represented by the line M, is for each curve in the vicinity of 40 cm.

Thus in the Barents Sea with its intact stock of plaice, the mode of the length frequency curve (Fig. 2), viz., 46–47 cm,, is some 7 cm. *higher* than the average size at first maturity, viz., 39–40 cm. On the other hand, in the diagram (Fig. 3) representing the stock in the central parts of the North Sea, we should naturally not expect to find any such great accumulation of mature fish; but it is somewhat alarming to find that the mode here (36–37 cm.) fails by 3 cm. to reach the average size at first maturity (39–40 cm.). That is to say, some factor is at work which keeps down the plaice population to such an extent that *the greater proportion are not, at the present time, once permitted to reproduce their kind.* If we compare this with Dr. Petersen's previous discussion of these points in his paper, "What is over-fishing?" (*Journ. M. B. A.*, Vol. vi., 1903, pp. 587–94), it would appear as though the chief theoretical effects of over-fishing in the North Sea, suggested in that paper, were now being substantiated.*

It may be that this enormous contrast is partly due to the fact that

* KYLE (*Journ. M. B. A.*, Vol. vi, p. 496) suggests that one effect of fishing a plaice population is to reduce the average size at first maturity. The Barents Sea will afford the opportunity of testing this; meanwhile, if we were to accept the suggestion that such a reduction has taken place to the extent of, say, 5 cm. in home waters, the deterioration of the stock would be still more evident, and even a greater proportion of North Sea plaice than my curves tend to show would be prevented from attaining maturity.

the fish dealt with in the Barents Sea were possibly selected naturally by the function of spawning, and that immature fish had not migrated so far seawards to an appreciable extent. I think this is in part probable, and that in the North Sea a similar state of affairs may have once obtained, but has now undergone the following change :—

Formerly the plaice population was dense on suitable areas, from the nursery grounds out to such a central ground as the Dogger Bank, and the food supply was everywhere restricted. The early influence of man's fishing was to reduce the numbers of the largest fish at proportionally the greatest rate, and thus reduce the density of the population on the central grounds.

Better feeding conditions would now be afforded on the central grounds, and to these the younger plaice would tend to move more and more, as the reduction in the numbers of the older individuals became more appreciable. At the present time there seems no doubt that density of population is restricted to the nursery grounds, so it is to the advantage of the individuals to radiate rapidly to the more favourable surroundings offshore. Thus it may be that the larger of the immature plaice extend further seawards than was formerly the case, i.e., emigrate at an earlier age, in consequence of the reduced competition within the species on the offshore grounds.

At any rate, whether it was the case or not in former times, there is now to be found everywhere, and at all times in the North Sea, a proportion of immature fish many times greater than I found this year in the Barents Sea. Even amongst the spawning shoals in the North Sea it is quite usual to find as many immature female fish as mature.

On the other hand, it may possibly be that we have on this bank in the Barents Sea an accumulated stock of plaice such as the Norwegian investigators* have shown to have existed in suitable areas on their coast, on a much smaller scale. When these spots were first fished, quantities of large plaice were to be obtained. After a few years, however, the population appeared to have been almost entirely fished out, the explanation being that the currents, setting out of the fiords, carry the majority of the floating eggs and young fish to water in which they cannot develop. The capture of the stock is thus out of all proportion to its renewal by natural means, and the decay of the fishery in these particular spots is inevitable.

From this it would seem to be of the greatest importance for the future welfare of the plaice fishery in the Barents Sea, that steps should be taken to ascertain definitely whether extensive nursery

* *Report on Norwegian Fishery and Marine Investigations.* Vol. i., 1900, pp. 138–52.

grounds actually exist, from which the stock of the outer grounds may be renewed.

If the majority of the eggs and larvæ are carried by currents to regions in which they must naturally perish, as Hjort and Dahl (*loc. cit.*) have shown to be the case on parts of the Norwegian coast, it is evident that the fishery can only flourish so long as the present stock, accumulated through a great number of years, continues to be sufficiently abundant to pay for its capture.

It is not difficult to imagine that there may have been a period when the central grounds of the North Sea were inhabited by a plaice population, of which at least the majority of the individuals were mature; and, had we a curve of measurements of that period, the mode would conceivably have exceeded the average size at which the fish were first mature, by an amount as great as may now be found in the virgin waters of Northern Europe.

One of the earliest effects of fishing on any ground is to reduce the number of the large fish, and consequently lower the average size; that is to say, representing this effect on a diagram to compare with Figs. 2 and 3, the mode will recede to the left, and approach the size at which the species becomes mature.

If it is allowed that an accumulation of mature plaice once preponderated in the central North Sea, it will be obvious that the retrogression of this modal size to its present position (36–37 cm.) *below* the average size at first maturity (39–40 cm.) must have been effected gradually by the influence of man, for no serious natural enemy of large plaice in the North Sea is recognised, whilst the intensity of fishing is known to be very great.

Hence it is conceivable that if intense fishing continues, the modal size of the plaice will imperceptibly recede to even lower limits, and a period must arrive, if it is not already with us, when the supply of eggs, and consequently young fish, seriously suffers.

Summary.

In this preliminary investigation of the plaice on a bank in the Barents Sea the following were among the chief features noted:—

1. The population consisted almost entirely of mature fish, thus presenting a marked contrast to the conditions prevailing at the present day in the central parts of the North Sea (Dogger Bank, etc.).

2. The "average size at first maturity" for the females appears to be approximately the same (39–40 cm.) in the Barents Sea as in the central parts of the North Sea: but, whereas in the Barents Sea the

predominant size is several centimetres *above*, in the central parts of the North Sea it is several centimetres *below* that standard.

In other words, whereas on the virgin grounds of the Barents Sea the female plaice live to spawn many times, in the southern much-fished region the majority at the present time do not live to spawn once.

3. The number of rings on the otoliths indicate a remarkably slow rate of growth and great age attained in this region as compared with the North Sea. It also appears from these investigations that "biological spring," and also the spawning season, is some three to five months later than in the North Sea, viz. in mid summer.

4. On this voyage the differences in the proportions of the sexes at different sizes was striking. Up to a certain size (40–44 cm.) males were in great excess; after this, rapid diminution in their numbers took place.

In the North Sea the same two features have been found to occur, and are connected respectively with the spawning habits of the species and with earlier mortality of the male fish and its slower rate of growth.

5. Various evidence points to the existence of a spawning ground somewhat to the westward of the bank where the fishing took place.

Other Species.

The few other species which occurred during this voyage were as follows :—

Dab (*Pleuronectes limanda*).
Long Rough Dab (*Hippoglossoides platessoides*).
Halibut (*Hippoglossus vulgaris*).
Cod (*Gadus morrhua*).
Haddock (*Gadus aeglefinus*).
Catfish (*Anarrichas* (*minor* ?)).
Greenland Shark (*Laemargus microcephalus*).
Starry Ray (*Raia radiata*).
Lump-fish (*Cyclopterus lumpus*).
and *Cyclopterus* (*Eumicrotremus*) *spinosus, Müll.*
A Cottoid (*Gymnacanthus tricuspis*).

Dab (*Pleuronectes limanda*).

This species was of very rare occurrence in the area visited. Only four were observed, all being large; two of these measured 35 and 36 cm. respectively. On an otolith from the latter fish seventeen white rings appear very clearly, tending to show that the rate of growth of this species, like that of the plaice, is exceeding slow in these waters.

Long Rough Dab (*Hippoglossoides platessoides*).

This fish occurred in small numbers every haul. It appears to attain a much larger size here than in the North Sea, where the majority recorded by Fulton* are below 15 cm., and only an occasional specimen over 25 cm. A sample of 42 measured from one haul on the *Roman* ranged from 19–39 cm., the majority being between 25 and 29 cm. Slightly larger and smaller fish probably occurred, but no very small specimens were observed. The species is not brought to market at present.

Halibut (*Hippoglossus vulgaris*).

Four only were caught. Two measured 66 and 78 cm., the other two being a little larger and a little smaller than the lengths recorded. Examination of the otoliths of the fish 78 cm., a male, shows it to be apparently either seven or eight years old.

The species has but rarely been met with in the region, though from the Russian records it would appear to be more abundant further west. The specimens found on this occasion were probably all immature.

Cod (*Gadus morrhua*).

Small individuals occurred in practically every haul, and on one or two occasions in abundance.

A sample basket (52 fish) out of about three was measured from a haul on the second day, and the whole catch (51 fish) eight days later. The features presented by the tabulation of these measurements, if not accidental, are interesting.

In the first sample the sizes range 30–49 cm., with an exceptional fish 58 cm., the maximum number of measurements grouping about 40–42 cm.

The fish in the second lot had a range of size, 27–52 cm., with a very exceptional specimen 82 cm. The maximum of length frequencies occurs some 8 cm. lower, 32–34 cm., with a smaller maximum at 42 cm.

The possibility presents itself that two year groups are chiefly represented, the younger sparsely at the former station, and predominating at the latter, which would be further east than the early haul.

The above-mentioned specimen (82 cm.) was much the largest noted, other exceptionally large fish measuring 60, 69, 70, 77 cm., but never

* "Rate of Growth of Sea Fishes." Twentieth Annual Report, S. F. B.

more than one or two such large fish could be found in any haul. Mature cod at this time were thus practically absent from the area visited. Small codling have been found in quantities by the trawlers towards Bear Island.

Haddock (*Gadus aeglefinus*).

In the first haul (55 fms.) thirty fish were caught ranging from 24–34 cm.

Throughout the remainder of the voyage such small specimens were only rarely to be found. Very large fish up to 81 cm. were caught in quantities varying from one or two fish in a haul up to, on one occasion, 143 fish. These fish had evidently spawned some time previously.

An increase in the catch was noticeable in the few hours the sun was below the horizon.

In 1906* Dr. Hjort procured some large haddock from the catch of a Hull trawler which had been fishing in this region. His specimens were from 55–80 cm. in length, and their ages determined by investigation of the scales ranged between nine and fourteen years.

Catfish (*Anarrichas* (*minor ?*)).

I have records of this fish occurring regularly throughout the voyage in number from one to about a score a haul. With one exception (49 cm.) all the specimens were very large.

Two catches, 10 and 11 fish respectively, were measured, the range of size being 88–120 and 102–125 cm. These ranges and the quantity were typical of most of the hauls in the region at this time.

On various occasions stomachs of seven fish were examined. Crustacea (*Hyas*) and Mollusca appeared to be the staple food, though in one stomach I found three codling.

Greenland Shark (*Laemargus microcephalus*).

Called by the fishermen "oakettle."

Fourteen were recorded, but one or two more occurred. Of these fourteen, eight were measured, viz., 14 ft. (427 cm.), 12 ft. (366 cm.), 11 ft. 4 ins. (346 cm.), 10 ft. 6 ins. (320 cm.), two specimens 7 ft. (213 cm.), 6 ft. 10 ins. (208 cm.), and 5 ft. 6 in. (168 cm.). No very small specimens were found.

Difficulty was experienced in examining the stomach contents of

* JOHAN HJORT. "Nogle Resultater af den Internationale Havforskning," Saertryk af Aarsberetning vedk. Norges fiskerier, 1907.

these cumbersome creatures. Steam power was necessary to remove them from the remainder of the trawl contents, so that this and hoisting over the ship's side was made one operation. Before cutting the monsters adrift a lateral incision was made through which the liver was extracted.

To have opened the stomach as the fish lay upon the heap would not have improved the remainder of the catch. In two instances, however, I was able to examine the stomach contents.

In the first instance the food consisted of three codlings, about 40 cm., and a plaice of the same length. On the second occasion I found in a fish 6 ft. 10 ins. (208 cm.) in length two round fish (one probably a codling, about 60 cm. in length), one long rough dab, and a piece some twelve inches long from the mid-lateral region of one of the salmon species (*Salmo salar ?*) evidently a large fish.

Quantities of plaice could be observed at times pouring from the mouth of these sharks when suspended by the tail and lowered over the ship's side. That their depredations amongst the plaice are great, I feel convinced. I do not think the missing and damaged tails, so frequent as to be commonly noted by the fishermen, can be otherwise accounted for.

I have observed in the North Sea that when the dogfish (*Acanthias vulgaris*) feeds on small plaice, these are devoured from the tail first, in contrast to round fishes, such as herring, which are taken head first.

In my samples, the significant number of 113 fish, or nearly $2\frac{1}{2}$ per cent of the total, I found with tails more or less damaged, and subsequently healed; in some instances the whole tail had disappeared. The possibility of this phenomenon being the result of disease, such as is sometimes found to be destroying the tails and fins of fresh-water fish, would seem excluded, as the damaged extremities were clean and healthy. In the only exception the extremities of the tail rays were raw and bleeding.

All these facts, in conjunction with the concave shape of the majority of the assumed bites, seemed to me to point to the successful escape of the individual plaice from the jaws of a Greenland shark, though, as previously suggested, the possibility of depredations by seals must not be overlooked.

Starry Ray (*Raia radiata*).

This was the only ray species which occurred, and only occasional, full grown specimens were to be seen. Two female fish in one haul measured 35 and 37 cm. between the extremities of the pectoral fins. In the stomach of each of these was found two large specimens of the Arctic shrimp (*Sclerocrangon boreas*), identified by Mr. R. A. Todd.

Lump-fish (*Cyclopterus lumpus*).

One medium-sized specimen was found.

Lump-fish (*Cyclopterus* (*Eumicrotremus*) *spinosus, Müll*).

Two or three individuals of this lump-fish occurred during the first day or two of the voyage, but it was not observed afterwards.

A Cottoid (*Gymnacanthus tricuspis, Reinh.*)

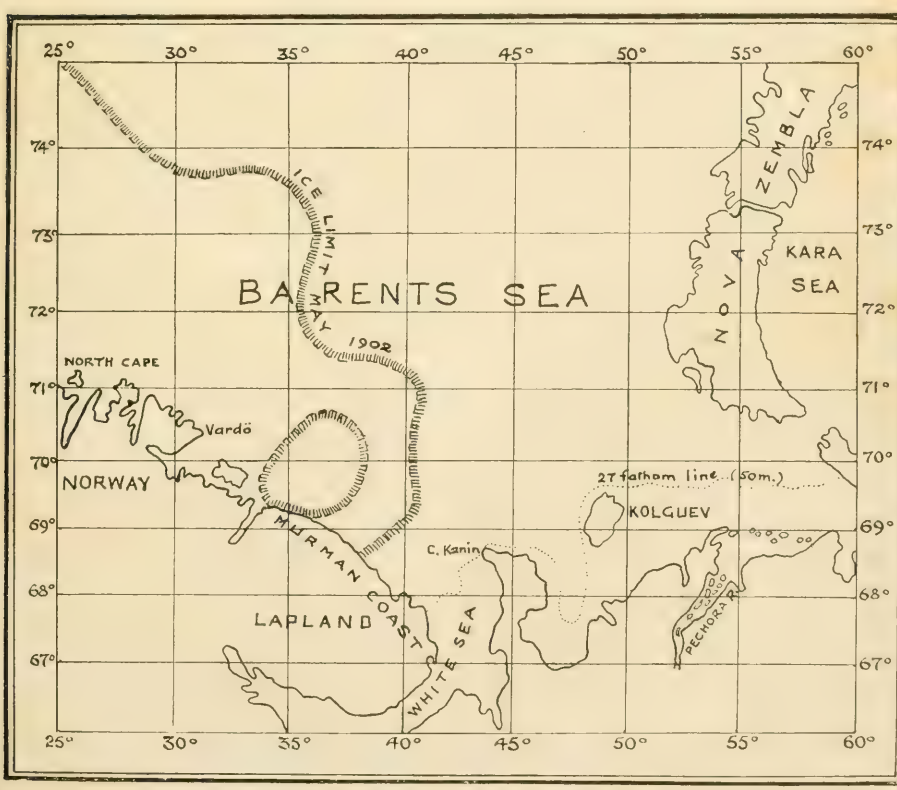
This was represented on the voyage of the *Roman* by one specimen. For the identification of this and the preceding species, my thanks are due to Mr. L. W. Byrne.

EXPLANATION OF PLATE IV.

Photograph of a three hours' catch of plaice in the Barents Sea (about 40 baskets), s.t. *Roman*, H 948, Aug., 1907.

General Chart of Barents Sea.

Photograph of a three hours' catch of plaice in the Barents Sea (about 40 baskets), s.t. *Roman*, H 948, Aug., 1907.



General Chart of Barents Sea.

To face p. 98.

Adapted by L. R. Crawshay from the Chart of the English Channel published by Imray, Laurie, Norie, and Wilson, 1906.

To face p. vv.

On Rock Remains in the Bed of the English Channel.

An Account of the Dredgings carried out by ss. "Oithona" in 1906.

By

L. R. Crawshay, M.A.

Assistant Naturalist at the Plymouth Laboratory.

With one Chart (Plate V) and two Figures in the Text.

In the programme of work for the summer of 1906, it was decided by the Director that a series of cruises should be carried out by the Association's steamer *Oithona* to investigate the fauna of the deeper waters of the English Channel. The bearing S.W. ½ S., Magnetic, = S. 23° W., True,* from the Eddystone Lighthouse was chosen as a base-line, and the work was to be carried out with special reference to points at 10-mile intervals along this bearing. The fauna was to be investigated as fully as possible, and bottom-deposits, particularly stones, were at the same time to be carefully recorded and collected. In all, eight cruises were made, the work being extended nearly as far as the 50-mile point.

Pending the completion of the report on the fauna collected, it has been decided to issue in a separate form an account of the geological collections that were made, which afford valuable evidence in the light they throw on the history of the Channel.

The stones, with which Mr. Worth's report deals copiously in a subsequent paper, were first found on June 11th at the close of the second cruise at Position (9), bearing S. 31° W. from the Eddystone, 22 miles, and at a depth of about 40 fathoms. The 3′ 0″ dredge was cast to try the nature of the bottom. After an unsatisfactory

* Except where otherwise stated, all bearings here given are true, a variation of 16° 45′ W. (say 17° W.) having been allowed throughout.

haul the arrangement of the gear was modified,* and as the result of a third attempt the dredge came up three parts full of stones. The contents of this haul were of so great interest that it was decided to investigate the subject further, and so far as was possible without unduly interfering with the faunistic work, the most careful attention was given during the subsequent cruises to tracing the extent of these stones and estimating the conditions associated with their occurrence.

In the third cruise, commencing on June 14th, the course was accordingly set to the position where they had been encountered. The stones were found again without difficulty, and were followed at close intervals during this cruise over a considerable area. Subsequently their inner limit was observed at points adjacent to the base-line of the work at some 15 miles outside the Eddystone. Beyond this their extent was still unknown, and much time was therefore occupied at first by short runs about the 20-mile point, which will explain the large number of positions shown on the chart in this region. Finally, from Position (37), S. 41° W., 17 miles, a test run of 12 miles was made in a south-westerly direction. The casting of the dredge at 6 and 12 miles showed rough ground at both points, one of the dredges being so bent out of shape as to be rendered temporarily useless. After this the work was extended on broader lines to the southward.

Some general points in connection with the stones will now be considered from evidence afforded in the course of the work. The extent of the area covered by the cruises is shown in the accompanying chart (Plate V), where the positions plotted are all of them directly concerned with the stones collected. All bearings and distances are reduced to the Eddystone Lighthouse. The work was done entirely by log and compass, no sextant observations being taken. At the same time much care was taken throughout with a view to securing as close a degree of accuracy as by dead reckoning was possible, and the positions given may be regarded as nearly accurate.

(1) *Extent of Exposure.*—The inner limit of the stones, as previously mentioned, was traced by two or three samples at about 15 miles outside the Eddystone. Here only a very few small stones were found, mingled with the sand and shell deposit which covers the sea-bottom. Inside this point, that is to say, between 8 and 15 miles

* That is to say, by attaching a heavy sounding-lead to the hemp warp employed, a few feet in front of the dredge. From this point the hemp warp was dispensed with, and a wire rope substituted for it in all dredgings.

outside the Eddystone, the dredges revealed nothing but clean shell-sand. Outside it, however, from the time when the gear was suitably adjusted to the work, there was no single point among the forty-five positions in which either of the larger dredges was used where stones were not found in greater or lesser degree. It may therefore be said that outside this 15-mile point a stony area was traced without interruption for a distance of 34 miles S.S.W. and for some miles to the eastward and westward of this line, covering a total area of some 300 square miles. At Position (80), the outermost point reached, bearing S. 16° W., 49 miles, which is slightly beyond the middle of the Channel, both the average size and the average weight of the stones collected were, with one exception, higher than anywhere observed, and there is every reason to suppose that beyond this point similar conditions prevail to within close proximity to the French coast.

(2) *Intensity.*—Of the distribution of the stones exposed in point of intensity it is more difficult to speak with assurance, so many are the factors which must enter into consideration: the character and possibilities of the gear employed, the variation of local conditions, and the tendency of the dredge to become quickly filled with animal débris in a particular spot, the general success of a haul dependent on tidal and weather conditions; all these tend to complicate the result as shown by the stones actually taken; so that it is difficult to form a just quantitative estimate without a more complete and systematic method of investigation than was possible in the circumstances. From the available data, however, there is little doubt that the stones lie scattered about the surface, with very little interruption over the whole area. In a table appended below (Table I, p. 114) detailed particulars are given of every sample obtained, including the estimated area covered by the dredge used. This estimate assumes an average rate of towing of one sea-mile per hour throughout. This cannot be regarded as more than a rough approximation, but it is sufficiently near for the general purpose. Excluding three hauls where no definite result was obtained owing to the dredge being fouled on obviously rough ground, the total area actually covered by the remaining 53 hauls amounts on this estimate to 11,950 square yards. The total number of stones of 4 cm. and over that were collected being 5808, an average ratio of distribution is obtained for the whole area of 0·5 per square yard.

Probably this estimate is somewhat short of the true state of things, for it does not take into consideration those stones which are too large to enter the opening of the dredge, nor does it make allowance for

the limited capacity of the dredge in regard to those positions where the stones are exceptionally numerous. But as a general estimate I do not think it is very far short of the truth, having reference, of course, only to stones exposed at the surface or very little covered. The most reliable test is probably to be found in the result of hauls with the conical dredge and the 1′ 6″ dredge. The former of these instruments is so constituted as to dig deeply with its heavy frame into the sea-bottom, and is therefore allowed to work only for a fraction of a minute, during which time the canvas bag with which it is fitted is rapidly filled with a complete sample of the bottom from a very small area, about 4 to 8 square yards. The 1′ 6″ dredge was also fitted with a canvas bag, and though not digging so deeply was used for a very similar purpose. Of five hauls with the conical dredge, from 19 to 49 miles, two produced no stones at all; of six hauls with the 1′ 6″ dredge, from 30 to 46 miles, three produced no stones at all; but if these 11 hauls be summarised, and the number of stones of 4 cm. and over be distributed over the sum of the estimated areas covered, a ratio of distribution is obtained for these short hauls very nearly equivalent to that for the whole area of the work, namely, 0·6 per square yard.

With reference to this absence of stones in five hauls with these small dredges, there is no doubt that the stones lie exposed on the sea-bottom very much more thickly in some places than in others, owing to the varying degree of sedimentary deposit in different areas dependent on tidal action and the physical conditions influencing animal settlement, and so regulating the local deposition of shell and other débris of animal origin. In the "Distribution" column of the table it will be seen that the ratio varies as widely as from 0·4 to 28·0 square yards per stone. An interesting case in point occurs in the Positions (10) to (13), S. 26° W., 18 miles. These four samples were taken in quick succession in a westerly direction over a distance of about 1 mile, and lying thus close together, are shown on the chart as coincident. It seems evident that here the dredgings passed through the middle of a stony patch which was almost covered by finer deposits at either limit.

At (10)	6	stones	were obtained	with an average distribution	of 1 stone to	28	sq. yds.
,, (11)	166	,,	,,	,,	,,	2	,,
,, (12)	187	,,	,,	,,	,,	1·8	,,
,, (13)	21	,,	,,	,,	,,	27·3	,,

To quote another instance, at Position (17), S. 28° W., 23·3 miles, a haul of 11 minutes with the 3′ 0″ dredge produced only 15 stones,

with the small mean dimension of 4·8 cm., and a distribution of 1 stone to 24·7 square yards. The dredge had here passed through a large and flourishing settlement of *Pallasia murata*, Allen, and a vast number of the tubes, together with several living specimens of this valuable Polychæte, were brought up in it with little else. As it was evident from the next haul, (18), that we had passed outside the limit of the *Pallasia* settlement, we steamed back to the ground of Position (17) in the hope of securing some more specimens, setting this run at half a mile. But the *Pallasia* ground was missed, and a very heavy haul of 34 stones was brought up at (19) with a mean greatest dimension of 10 cm., which was one of the highest averages obtained during the work. These two positions, (17) and (19), cannot have been separated by very many yards from one another, though the results obtained were totally different.

Again, the two blank hauls with the conical dredge previously referred to, (71) and (73), at 19 and 29 miles respectively, were followed in each case immediately afterwards by a haul with the 3′ 6″ dredge at (72) and (74). The first of these latter gave 213 stones with a mean distribution of 0·8 per square yard. In the second, the safety-stop of the dredge was broken, owing to the roughness of the ground passed, and no more definite conclusion was therefore obtainable than that very heavy stones had been encountered within about a quarter-mile of (73), where the conical dredge revealed only coarse shell-sand.

(3) *Size and Weight.*—A single greatest measurement of each of the stones was taken. Ultimately all stones of less than 4 cm. were left out of consideration, and a mean was obtained for each haul, derived from the products of dimension × number in each case, at intervals of 1 cm. Similarly, the samples were weighed, and a mean was worked out in pounds per stone, for each haul.

A cursory glance at Table I (p. 114) does not convey any very definite impression as to the relation between size or weight and distance of position from the Eddystone. A certain rate of increase occurs with distance, but it is very irregular. This is evidently due to the fact that the main bearing of the work does not lead directly out towards mid-Channel, but nearly four points to the westward. If a line be drawn due E. and W., Mag., through the Eddystone, a distinct increase is obtained, both in size and weight, in a direction perpendicular to this line, *i.e.* due S., Mag. Parallel lines being accordingly drawn E. and W., Mag., at 5-mile intervals outwards, and a mean being taken for all the samples falling within these several intervals, a fairly regular curve is obtained for both size and weight (pp. 105, 106).

The disposition of the samples is as follows:—

5–10 miles S., Magnetic	1 sample .	. .	43 stones
10–15 ,,	,, 18 samples	. .	2924 ,,
15–20 ,,	,, 13 ,,	. .	1765 ,,
20–25 ,,	,, 3 ,,	. .	334 ,,
25–30 ,,	,, 7 ,,	. .	424 ,,
30–35 ,,	,, 7 ,,	. .	455 ,,
35–40 ,,	,, 2 ,,	. .	22 ,,

The area between 20 and 25 miles, represented by three samples, should properly include the sample (74) previously referred to, where the stop of the dredge being broken, owing to the roughness of the ground, no numerical results were obtainable, and the position had therefore to be left out of consideration. There is little doubt therefore that it is owing to an insufficient number of samples that a drop occurs over this area in both curves.

In point of size and weight, then, there is a steady increase correlated with distance in a mid-Channel direction. For the location of the samples, the bearing and distance of all the positions has been reduced to the Eddystone; but the main bearing of the work being S. 23° W. from this point, that is, almost directly on Ushant, their location must be regarded from a different standpoint, where questions are involved relating to their distance from the English coast. Treating the Eddystone as an outlying point on the coast-line, a line running through it E. and W., Mag. will be roughly parallel to the mid-Channel line, and less than one point off the main direction of Hurd Deep. Outside it the positions fall naturally into the groups from which the curves (Figs. 1 and 2) are obtained at 5-mile intervals, as follows:—

5–10 miles.	37.
10–15 ,,	36, 31, 32, 35, 33, 34, 10, 11, 12, 13, 39, 40, 9, 16, 15, 72, 26, 27.
15–20 ,,	14, 20, 21, 22, 29, 30, 34, 25, 17, 19, 18, 42, 41.
20–25 ,,	73, 74, 43, 47, 44.
25–30 ,,	55, 56, 53, 44, 50, 51, 58.
30–35 ,,	58, 75, 67, 76, 77, 63, 62.
35–40 ,,	79, 80.

In connection with the foregoing deductions, two points may here be considered: (1) the size of the stones in relation to that of the opening of the dredge frame; (2) the position in which they lie.

In regard to the first point, the 3′ 6″ dredge, the largest used, with a frame of 3′ 6″ × 1′ 0″, offered an opening of about 100 × 30 cm. Similarly the 3′ 0″ and triangular dredges allowed of stones at least

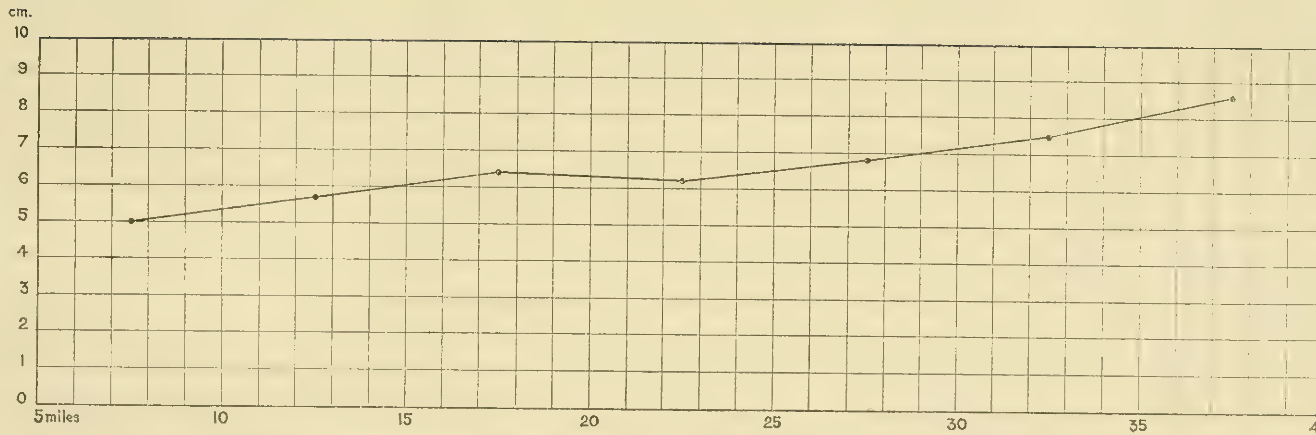


FIG. 1.—Average greatest dimension of stones for 5-mile intervals S. 17° E. from Eddystone.

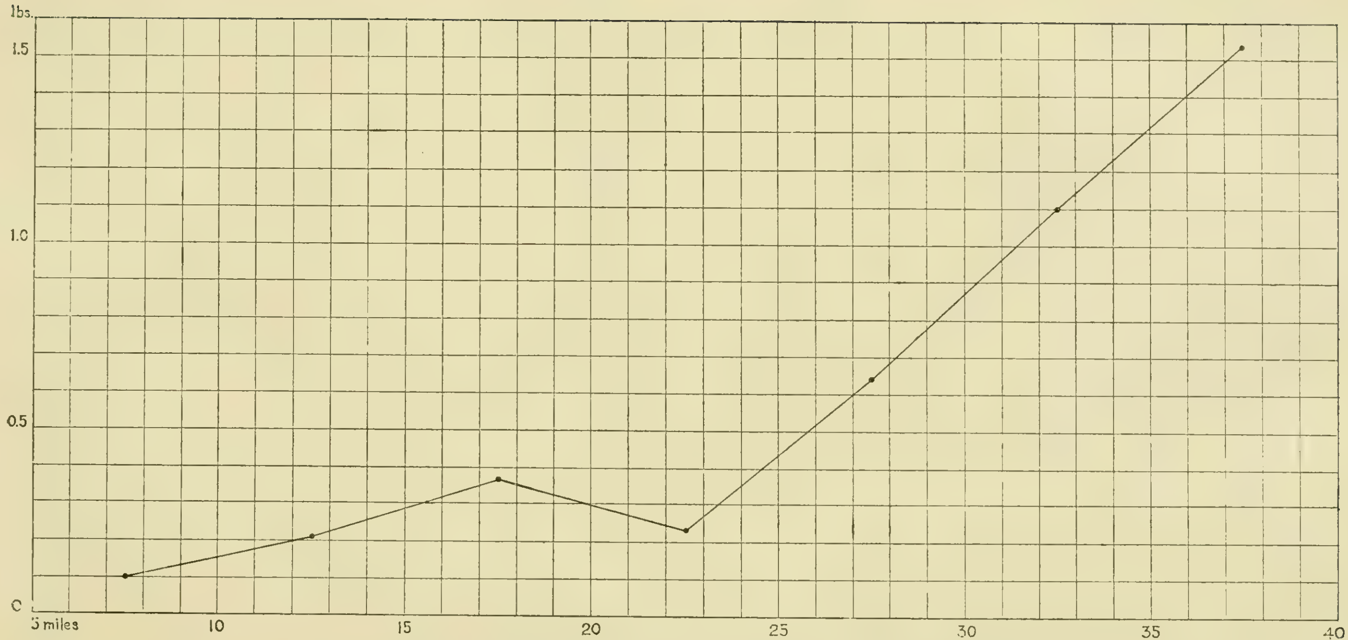


FIG. 2.—Average weight of stones for 5-mile intervals S. 17° E. from Eddystone.

as large as 90 cm. and 50 cm. being taken. But it is significant that in forty-five hauls with these three dredges, no stones with any approach to such a size, even in their greatest dimension, were obtained. Among the largest were—

four of 20 cm. on (19), (77), and (58)
five of 21 „ „ (19), (58), and (62)
four of 22 „ „ (19), (53), and (67)
one of 26 „ „ (58)
two of 27 „ „ (53) and (80)
one of 30 „ „ (77)

It may therefore be concluded that, except, of course, in so far as they are largely or wholly covered up, very large stones are not very numerous in this area, and the dimensions and weights shown on the curves may be taken as a fair approximation to the true average. There is no doubt, however, that very large stones and even boulders do occur with considerable frequency, as on the trawling-grounds off Start Point. The heavy working of the dredge communicated through the warp, the breaking of the safety-stop, and the bending or even breaking of the ironwork of the dredge afforded frequent evidence of this. A broken stop occurred at the following points:—

(38), S. 38½° W., 22·2 miles
(39), S. 38° W., 22·2 „
(18), S. 29° W., 23·4 „
(62), S. 25° W., 46·4 „

At (21), S. 25° W., 21·2 miles, the 3′ 0″ dredge employed was brought up fast and lost, only a portion of one arm being recovered.

To break the safety stop, a strain is required of some 600–700 lbs. To sharply open out the wrought-iron frame of the dredges used, in the manner that too often occurred, involves a strain of several hundredweight; while in the total loss of the dredge at (21), the parting of the remaining arm would only be caused by a strain of about twelve tons. At some of these points, then, and at (21) in particular, heavy boulders must have been encountered, the size of which can only be estimated at a rough minimum.

As regards the second point, the position of the stones as they lay when dredged up, there is ample evidence to show that, with very few exceptions, they were well exposed at the surface of the sea-bottom, and that they have probably so lain for a considerable time past. Almost without exception, they supported living animal growth or its remains—Porifera, Hydrozoa, Polychæta, Polyzoa, Mollusca, etc. Scarcely any of the stones were without investing Polyzoa, which often covered the greater part, sometimes the whole, of the surface.

A large majority supported living Hydrozoa, in addition. The animal growth often showed well-marked limits above an underlying bare portion on which the stone had rested in its bed, evidently undisturbed for a long period of time. Such a position, with the greater part of the stone exposed, was the commonest; but in places, especially near mid-Channel, on (80), S. 16½° W., 48·9 miles, evidence pointed to the stones resting more openly on one another, with very little fine deposit associated with them. Under the more ordinary conditions, with the exposed stones lying scattered about at intervals of a yard or two, in an even shelly or sandy bed, it is not surprising that the bottom of the Channel has been so widely charted as sand and shell, the lead rarely happening to strike these stones except in places where they are exposed to an abnormal degree. There is much reason to believe that the intervening deposit of shell and sand forms for the most part only a thin covering, and that if this could be penetrated to a depth of not many inches, the true bottom of the Channel over the whole of this area would be revealed as an uninterrupted stony bed.

(4) *General Form.*—The stones exhibited every gradation of form, between that of perfectly rounded outline and sharp angulation; the fact that numerous examples of these two extremes repeatedly occurred in the same sample is sufficient to show that little or no wearing action has taken place in recent times. Frequent instances occur of a sequence of events: (1) complete rounding; (2) sharp fracture; (3) secondary rounding; but the ultimate investment of animal growth afforded constant evidence in such cases of the secondary rounding not being recent.

(5) *Bottom-Deposits.*—Thirteen hauls were taken with the conical and 1′ 6″ dredges, two of them being from positions at eight to nine miles outside the Eddystone, and therefore well inside the point where the stones first appear. I am indebted to Mr. R. A. Todd for his assistance in grading the whole of these samples. The results are given in Table II (p. 117), where the samples are arranged in order of their distance on a S.W., Mag. bearing from the Eddystone. The method of grading is that adopted at the Lowestoft Laboratory for estimating the texture of bottom-deposits in connection with the International Fishery Investigations. The material is separated into eight grades by washing it successively through a series of sieves with circular perforations of 15 mm., 10 mm., 5 mm., 2·5 mm., 1·5 mm., 1·0 mm., and 0·5 mm., the residue which passes through the 0·5 mm. sieve forming the eighth grade. The exceptionally high proportion of "shell" contained in these samples, that is to say, fragments of the shells of Mollusca, fragments of plates and spines of Echinodermata,

and fragments of Polyzoa, especially *Cellaria* and *Cellepora*, rendered the accurate grading of them a difficult matter, owing to the repeated breaking of the more delicate fragments in the sifting process, so that some small excess error must be allowed for throughout in the direction of the finer grades. The percentage of Carbonate of Lime present in the material above and below the dimension of 0·5 mm. has been determined as shown in Table II. The proportion of this due to inorganic matter is so slight that the percentage may be treated as representing entirely organic remains. For convenient comparison of the samples an "average grade" is added in each case. This method of averaging the samples, which was used by Mr. Worth in estimating the texture of bottom-deposits of the Start to Eddystone Grounds,* consists in multiplying each grade-percentage by its conventional number (15 mm. + = I, . . . ∠ 0·5 mm. = VIII,) and then dividing the sum of the products by 100, the quotient being the average grade of the sample. It is an interesting point to observe that in these samples, as is shown in Table II, there is a distinct tendency for the average grade to decrease, *i.e.* for the texture to become coarser, with the increase of distance outwards, as far as (75) at 38 miles, beyond which an increase occurs up to (79) at 48 miles. If these few samples be grouped together on broad lines of 10-mile intervals on a S.W., Mag. bearing, the combined averages appear as follows:—

5–10 miles . .	2, 69, .	Average Grade, 7·576
10–20 ,, . .	71 . .	,, 6·524
20–30 ,, . .	73, 48, 50 .	,, 6·480
30–40 ,, . .	50, 75, 76 .	,, 5·255
40–50 ,, . .	65, 61, 79 .	,, 5·033

Sample (50), falling on the 30-mile point, is included in both intervals between 20 and 40 miles.

While this method of averaging is useful as indicating the comparative texture of the samples, it is open to the objection that the inclusion of the coarser grades may unduly influence the result in the way of obscuring the finer ones. If the coarser grades be disregarded, and only those below and including 1 mm. + be considered, the average percentage of material within this range for the samples grouped in the same manner as before works out as follows:—

5–10 miles	95·0 per cent.
10–20 ,, ...	77·1 ,,
20–30 ,, ...	76·2 ,,
30–40 ,, ...	52·1 ,,
40–50 ,, ...	41·6 ,,

* *Journal of the Marine Biological Association*, Vol. V, p. 381.

In most of the samples the smaller particles, both organic and inorganic, show a good deal of rounding and often a high polish, and in all of them there is almost or entirely an absence of silt.*

Few as these samples are and irregularly disposed over so great a distance, the fragmentary evidence afforded by them is important in its bearing on the final question to be dealt with.

(6) *Conclusion.*—One point remains to be considered in conclusion. How is the exposure of these stones at the present time to be accounted for? The Channel bottom is probably disturbed to a considerable depth by wave action in stormy weather, though to what degree is a matter yet to be investigated. Fine particles of sand and other matter have often been taken in the tow-net at a considerable distance from the bottom, and even at the surface, in water as deep as in any part of the Channel. It would be difficult not to attribute this, in some degree, to wave action. It is commonly asserted by fishermen that on the trawling-grounds off the Start, in 35 to 40 fathoms, they are much more liable to have their trawls fouled by large stones immediately after stormy weather than at other times, the belief prevailing that at such times the boulders become more exposed owing to the disturbance of the fine deposit. A case in point occurred quite recently (December 15th, 1907), after an exceptionally rough spell of weather, when some of them encountered heavy stones on these grounds, and by one of them, the Brixham trawler *Love and Unity*, a block of granite was brought into Plymouth weighing 833 lbs.† Probably there is much truth in this impression, and the influence of wave action should be considered as partly contributing to the continued exposure of the stones far out in the Channel. But the direct agent must be sought for in the tides, and I think it will be found that the tidal conditions in this region are sufficient to explain the cause at work.

As far at least as about the 40-mile point referred to in these cruises, there appears to be a constant gain on every complete tide in a north-easterly direction. The meridian of the Eddystone is roughly the western limit of the conflicting tidal conditions caused by the Dover Stream, involving at intervals an opposite direction of the current in the easterly and westerly portions of the Channel. When in this westerly part of the Channel the tide turns to flow, it has to encounter, to the southward of the Eddystone, a still strongly ebbing stream from Dover. Aided by the northerly set from the Bay of Biscay, it is forced against this in such a way as to be deflected to the

* *i.e.* matter which remains in suspension in water at the end of one minute.

† This stone is referred to by Mr. Worth on p. 122.

northward and north-eastward, and it is only when the Dover ebb has slackened, some time afterwards, that the direct up-Channel flood can be resumed. On the turn to the ebb the case is different. The two streams simply flow away from one another, and there is very little or no appreciable deflection through the south. While there cannot perhaps be much doubt as to the existence of this north-easterly gain, nearly as far, at least, as mid-Channel, the existing data available are too incomplete to admit of its being definitely estimated with confidence as to the result. I have made reference to the surface current measurements as shown in the *English and Irish Channel Tidal Streams,* compiled for the Admiralty by Commander Simpson, R.N., and in order to form some estimate on this basis the measurements of the mean current between neaps and springs for each hour were combined, and a mean resultant worked out for one complete tide at 10-mile intervals S. 23° W. from the Eddystone. The values thus obtained are as follows:—

Eddystone N. 23° E.,	10 miles .	.	N. 24° E., 2·2 miles
,, ,,	20 ,, .	.	N. 21° E., 1·3 ,,
,, ,,	30 ,, .	.	N. 26° E., 1·1 ,,
,, ,,	40 ,, .	.	N. 39° E., 1·2 ,,

These results must, of course, be treated with reserve. In the first place, they are derived from measurements in which, admittedly, too great reliance must not be placed on detail; and in the second place, they are surface measurements, and, however accurate as such, do not necessarily represent the condition of things at the bottom. But they show a remarkable degree of regularity in the general result, which seems to justify their being given here. The most doubtful point is that at 50 miles, where different conditions arise with the commencing approach to the French coast, and there is more southerly drift than at the other points. Owing to the difficulty of estimating closely from the tidal charts the force and direction of the current here at some intervals of the tide, the position has been left out of consideration. Close to this point, Mr. D. J. Matthews has made, from time to time, a number of measurements with the Ekman-Nansen current meter. In August, 1905,* he was able to carry these observations through one complete tide at different depths. From his 22 measurements at the surface on this occasion I have derived a resultant of S. 4° W., 0·96 mile. At 70 metres, however, his 18 measurements give a resultant of S. 21° E., 0·40 mile. The gain at this point would therefore seem to be a southerly to easterly one. The most important

* *Conseil Perm. Internat. pour l'Expl. de la Mer. Bulletin Trimestr.* August, 1905. Part B., p. 25.

point in Mr. Matthews's observations in the present connection is the fact that he has found a stronger current at 70 metres than at the surface. On this occasion, which was about the time of three-quarter Springs, it amounted to as much as 1·3 miles per hour. In the preceding May,* he made, on the same station, a series of measurements at 90 metres *i.e.* close to the bottom, extending through almost one complete tide, but not, unfortunately, in quite sufficient detail to admit of a resultant being taken. The force of current then measured rose to as much as 0·5 mile per hour, and as it was only one day subsequent to the date of the Moon's first quarter, one may fairly safely assume at high Springs a bottom velocity, at this point, reaching 1·5 knots or more.

It is on this latter point that the main question turns concerning the exposure of the stones. If it should be true, as evidence seems to point, that there exists a constant tidal gain on the English side of mid-Channel in a north-easterly direction, and in the more central waters, as would seem from Mr. Matthews's observations towards the south-east and south, this fact, combined with the presence of a bottom current reaching as much as 1½ knots, would be sufficient to explain the exposure of stones. No fine deposit could accumulate with this gradual shifting process constantly at work in the outer waters of the Channel. It must be passed on elsewhere, perhaps to come to rest ultimately off the English coast-line, or, on the other hand, it may be, to be carried through the south towards the Atlantic. The evidence afforded by the bottom-samples that were taken with the conical and 1′ 6″ dredges tends to support this conclusion. Outside about ten miles from the Eddystone no instance was found of what could, strictly speaking, be called a fine deposit. Beyond this point the deposits obtained might be described in general terms as coarse shell-sand mingled with fine or coarse gravel and usually stones, with a very small proportion of quartz grains. Except in sample (50), S. 16° W., 30·9 miles, the material above 1 mm. in grade comprehended within the range of Table II, amounted in all cases to more than 30 per cent of the sample. In most of them it exceeded 50 per cent. Sample (50), moreover, cannot by any means be regarded as of a fine grade, since it also contained in addition to the finer deposit indicated in Table II, several stones with an average greatest dimension of 6 cm.† Further, it has already been pointed out (p. 109) that this coarser texture of

* Id. May, 1905. Part B., p. 94.

† The same point applies to several of these bottom-samples, in which the inclusion of stones would have been too cumbersome for the purposes of Table II; cp. especially sample 79 (Table I, p. 116), where the larger stones averaged 0·67 lb. per stone.

the bottom deposit increases with distance outwards, or conversely, the percentage of the finer deposit increases as the coast-line is approached, till at some eight to ten miles outside the Eddystone there is found, in 40 fathoms, a deep accumulation of fine sand, 92 to 95 per cent of which is less than 1 mm. in grade.*

It would be difficult to account for these facts except on the assumption that there is a constant tendency for the finer material to be drifted, by combined tidal and wave action, from the outer waters of the Channel towards the coast-line, the direction of the drift being apparently, so far as the English side of the Channel is concerned, north-easterly. On such an assumption, with the continuous transportation of the finer material from the more distant positions, the greater degree of exposure of the stones in like proportion would be accounted for. Without the presence of a constant process of the kind no explanation would seem adequate to account for the fact that in the midst of shifting deposits brought from other regions and continuously augmented by the local growth and decay of numerous lime-secreting organisms, even small pebbles of no more than a centimetre or two in height are found again and again, affording an undisturbed base for delicate animal growth, evidently for a long period.

Whether the present conditions are undergoing any change, or whether they represent a state of equilibrium maintained between the factors of deposition and tidal action it would be of deep interest to know. In either case there is very little doubt that at the present time, over almost the whole of this area, the true stony bed of the Channel is but barely obscured by a very thin, superficial covering.

* It must, however, be expressly stated that it is not intended here to assign to this last formation, represented by the samples (2) and (69), an *origin* in the outer waters of the Channel. The inference is rather that somewhere between it and the region of sample (71) the outer Channel drift encounters an opposing action of coastal currents, to which latter it would seem that this distinct deposit is properly to be ascribed, thus preventing its further distribution seawards and deflecting the outer Channel drift itself from the actual coast-line.—L. R. C.

Table I.

DETAILS OF HAULS, WITH AVERAGES OF SIZE AND WEIGHT AND ESTIMATED INTENSITY OF THE STONES, AS EXPOSED.

Sample.	True bearing from Eddystone.	Distance. Miles.	Depth. Fathoms.	Gear used.	Length of haul. Minutes.	Estimated area covered. Sq. yds.	Weight of total sample. lbs.	Stones of 4 cm. and over. Number.	Arithmetic mean c.m.	Ratio of distribution. 1: sq. yds.	Average weight. lbs.	General character of bottom-deposit.	Remarks.
31	S. 25° W.	15·0	40	3 6″ dredge	10	395	8·5	65	5·1	6·0	0·13	[Shell]	
32	S. 25° W.	16·3		,, ,,	7	276	3·0	16	4·6	17·2	0·19		
37	S. 41° W.	17·1		,, ,,	9	355	4·5	43	5·0	8·3	0·10	[Shell-sand and some gravel]	
36	S. 37° W.	17·5	43	,, ,,	8	316	43·0	190	5·9	1·7	0·23		
33	S. 25° W.	17·5		,, ,,	7	276	56·0	289	5·5	1·0	0·19		
10	S. 26° W.	17·8	42½	3′ 0″ dredge	5	169	0·5	6	5·6	28·0	0·08	[Shell]	
11	,,	,,	,,	,, ,,	10	338	59·0	166	6·4	2·0	0·35	[Shell]	
12	,,	,,	,,	,, ,,	10	338	39·0	187	5·9	1·8	0·21	[Shell]	
13	,,	,,	,,	,, ,,	17	574	6·0	21	6·0	27·3	0·28	[Shell]	
35	S. 32° W.	18·0		3′ 6″ dredge	8	316	50·0	227	5·9	1·4	0·22		
27	S. 19° W.	18·3	44	Triangular dredge	8	173	27·5	147	5·6	1·2	0·19	[Shell and gravel]	
26	S. 20° W.	18·4	44	,, ,,	8	173	27·5	156	5·5	1·1	0·18		
34	S. 28° W.	18·5		3′ 6″ dredge	8	316	61·0	298	5·9	1·1	0·20		
71	S. 23° W.	19·0		Conical dredge	¼	4	—	—	—	—		Shell-sand and gravel	
72	S. 23° W.	19·0		3′ 6″ dredge	7	276	57·0	213	6·3	1·3	0·27	[Shell and gravel]	
29	S. 14° W.	19·8	44	Triangular dredge	7	151	74·0	295	5·9	0·5	0·25	[Coarse gravel and shell]	
14	S. 24° W.	20·0		3′ 0″ dredge	15	506	174·0	711	6·0	0·7	0·24	[Gravel]	
15	S. 27° W.	20·3		,, ,,	10	338	34·0	144	6·2	2·3	0·24		
20	S. 25° W.	20·5	44	,, ,,	10	338	44·0	162	6·2	2·1	0·27		
16	S. 29° W.	20·9	44	,, ,,	10	338	24·0	105	6·0	3·2	0·23	[Shell and gravel]	
21	S. 25° W.	21·2		Triangular dredge	9	194	49·5	162	6·2	1·2	0·31	[Shell and gravel]	After having brought up with & lost 3′ 0″ dredge.
30	S. 21° W.	21·5	43½	,, ,,	10	216	8·0	22	6·4	9·8	0·37	[Shell]	
9	S. 31° W.	21·7		3′ 0″ dredge	20	675	101·0	435	5·9	1·5	0·23		
40	S. 38° W.	21·7	44	Triangular dredge	5	108	38·0	256	5·6	0·4	0·15	[Broken shell and gravel]	

Sample.	True bearing from Eddystone.	Distance. Miles.	Depth. Fathoms.	Gear used.	Length of haul. Minutes.	Estimated area covered. Sq. yds.	Weight of total sample. lbs.	Stones of 4 cm. and over. Number.	Arithmetic mean. c.m.	Ratio of distribution. 1: sq. yds.	Average weight. lbs.	General character of bottom-deposit.	Remarks.
22	S. 25° W.	21·9	44	Triangular dredge	4	86	4·5	26	4·8	3·3	0·17	[Shell-sand and gravel]	
39	S. 38° W.	21·9	44	3′ 6″ dredge	4	158	—	—	—	—	—		Stop broke. Arm bent. Rough ground. 3 stones with mean of 5·3 cm.
38	S. 38½° W.	22·2	44	3′ 6″ dredge	7	276	—	—	—	—	—		Stop broke. Frame bent. Very rough ground.
24	S. 24° W.	22·5		Triangular dredge	5	108	41·0	152	6·0	0·7	0·27	[Shell-sand and gravel]	
25	,,	23·0	46	,, ,,	8	173	13·0	86	5·3	2·0	0·15	[Shell and small gravel]	
17	S. 28° W.	23·3	45	3′ 0″ dredge	11	371	2·5	15	4·8	24·7	0·17	[Shell and *Pallasia* tubes]	*Pallasia murata* ground.
19	,,	,,	45	,, ,,	10	338	34·5	34	10·0	9·9	1·01	[Shell]	Having steamed back ½ mile with intention of striking same ground as (17).
18	S. 29° W.	23·4	45	,, ,,	10	338	6·5	32	6·1	10·6	0·20		Stop broke.
42	S. 36° W.	26·4	44	Triangular dredge	6	130	6·5	53	4·4	2·4	0·12		
41	S. 36½° W.	26·6	44	,, ,,	7	151	20·5	15	10·7	10·0	1·37	[Stones]	
43	S. 21° W.	28·8	45	,, ,,	10	216	51·5	179	6·8	1·2	0·29		
73	S. 24° W.	28·8		Conical dredge	(a few seconds)		—	—	—	—	—	Coarse shell-sand	
74	,,	,,		3′ 6″ dredge	4	158	—	—	—	—	—		Stop broke. Rough ground. A few stones of 4–5 cm. brought up.
47	S. 19° W.	29·7		1′ 6″ dredge with canvas bag	½	8	4·5	20	6·3	0·4	0·22		
44	S. 17° W.	29·8	46½	Triangular dredge	10	216	23·0	135	5·6	1·6	0·17		
48	S. 11° W.	30·5		1′ 6″ dredge with canvas bag	½	8	—	—	—	—	—	Shell-sand	
51	S. 15° W.	30·8	43	Triangular dredge 3′ 6″ ,,	5 10	108 395 } 503	9·5	46	5·1	10·9	0·21		Two consecutive samples were numbered "51" in error and are therefore combined.
50	S. 16° W.	30·9	43	1′ 6″ dredge with canvas bag	2	34	3·5	7	6·0	4·8	0·50	Shell-sand	
53	S. 22° W.	32·2	46	3′ 6″ dredge	10	395	7·5	52	6·7	7·6	0·14	[Shell and gravel]	
56	S. 25° W.	34·3	49	Triangular dredge	4	86	27.5	124	5·1	0·7	0·22	[Broken shell and gravel]	

TABLE I.—*continued.*

Sample.	True bearing from Eddystone.	Distance. Miles.	Depth. Fathoms.	Gear used.	Length of haul. Minutes.	Estimated area covered. Sq. yds.	Weight of total sample. lbs.	Stones of 4 cm. and over. Number.	Arithmetic mean. c.m.	Ratio of distribution. 1: sq. yds.	Average weight. lbs.	General character of bottom-deposit.	Remarks.
55	S. 25½° W.	34·4	49	1′ 6″ dredge with canvas bag	1	17	8·5	39	5·8	0·4	0·22		
75	S. 20° W.	38·1	49	Conical dredge	⅓	6	8·0	9	6·8	0·7	0·90	Stones, gravel, and broken shell	Very rough ground.
77	S. 11° W.	38·8	49	3′ 6″ dredge	7	276	103·0	57	10·6	4·8	1·80	[Shell and stones]	
76	S. 9° W.	38·9	49	Conical dredge	½	8	—	3	5·0	2·7	—	Coarse shell-sand	
58	S. 22° W.	39·0	49	3′ 6″ dredge	10	395	62·0	21	13·0	18·8	3·00	[Broken shell and gravel]	
67	S. 19° W.	40·5		Triangular dredge	10	216	22·0	48	6·4	4·5	0·46	[Shell]	
65	S. 22° W.	42·2	52	1′ 6″ dredge with canvas bag	1	17	—	—	—	—	—	Coarse shell-sand	
61	S. 25° W.	46·4	50	1′ 6″ dredge with canvas bag	1	17	—	—	—	—	—	Coarse shell-sand and gravel	
62	S. 25° W.	46·4	50	3′ 6″ dredge	7	276	88·5	268	5·3	1·0	0·33		Stop broken after very heavy work.
63	S. 25½° W.	46·8	50	Triangular dredge	7	151	6·0	49	5.4	3·1	0·12	[Shell and gravel]	
79	S. 16° W.	48·7	51	Conical dredge	¼	4	2·0	3	7·6	1·3	0·67	Coarse shell-sand and gravel	
80	S. 16½° W.	48·9	51	3′ 6″ dredge	7	276	46·5	19	9·6	14·5	2·44	[Stones]	

NOTE.—In the last column but one of the above table the term "gravel" is employed to designate inorganic material ranging in greatest dimension from about 1·5 to 20 mm.

In the same column the entries enclosed in square brackets have reference only to such fine material as was retained with the general contents of the haul, in dredges with a more or less open mesh. They have not, therefore, the same completeness as the others.

Table II.

TEXTURE OF BOTTOM DEPOSITS, AS SHOWN BY SAMPLES TAKEN WITH CONICAL DREDGE AND 1′ 6″ DREDGE.

Sample.	Distance on S.W. Bearing (mag.). Miles.	Weight treated. Grs.	Percentage of Grades (Grades in mm.).								Percentage of $CaCO_3$.		Average Grade.
			15·0+	10·0+	5·0+	2·5+	1·5+	1·0+	0·5+	<0·5	>0·5	<0·5	
2	8	798·0	1·4	0·5	0·5	0·2	0·4	1·3	9·7	86·0	73·4	20·5	7·704
69	9	1204·0	3·7	1·2	0·7	0·4	0·7	1·6	10·0	81·5	75·4	19·5	7·449
71	19	1032·0	2·6	1·3	2·2	6·8	10·1	8·6	36·7	31·8	77·6	32·3	6·524
73	29	1012·0	0·2	0·1	1·0	10·7	18·7	24·0	37·1	8·3	69·4	32·5	6·098
48	29	849·0	—	0·2	1·8	8·8	14·1	19·7	29·5	25·8	87·5	28·8	6·426
50	30	874·0	—	0·1	0·7	5·8	8·9	12·2	28·3	43·8	92·8	36·5	6.917
76	37	1116·0	7·4	8·9	12·8	11·2	7·0	4·2	14·4	33·9	63·9	66·3	5·406
75	38	872·0	19·1	21·2	21·8	12·2	5·9	4·7	7·5	7·3	41·6	68·7	3·443
65	42	1052·0	8·1	10·4	15·3	21·1	6·7	4·3	15·4	18·7	69·7	49·8	4·759
61	46	855·0	0·2	1·0	8·9	34·3	22·6	13·2	16·4	3·4	91·2	41·0	5·003
79	48	917·0	6·2	6·2	9·5	15·2	9·5	11·9	25·9	15·7	82·8	47·8	5·337

Samples (47) at 29 miles and (58) at 39 miles contained no fine deposit, only stones being brought up.
Stones of 4 cm. and over are left out of reckoning in this table.

The Dredgings of the Marine Biological Association (1895–1906), as a Contribution to the Knowledge of the Geology of the English Channel.

By

R. Hansford Worth, F.G.S.

With Plates VI–XVII (including five charts) and four figures in the Text.

INTRODUCTION.

INVESTIGATION of the geologic problems connected with the English Channel is no new matter. Setting aside all speculations deriving from the study of its coast-line, the first serious examination of the bed of the Channel was made by R. A. C. AUSTEN, and his results published in the *Proceedings of the Geological Society*, 13 June, 1849. Although, as he states, he had examined the sea-bed with dredge and sounding-lead he has little to say as to its lithology. But none the less his work is a notable contribution to our knowledge, and his conclusions bear well the test of subsequent discoveries. Following AUSTEN, in 1871, DELESSE published his *Lithologie des Mers de France*, in which considerable attention is given to the Channel; and the lithology of its coastal deposits, and to some extent of the sea-bed, is considered in detail. But, valuable as this work is, its chief interest lies in the information given as to the nature of the sea-bottom, the grade and extent of the varying deposits. AUSTEN and DELESSE alike, and in agreement, point out the large areas of the Channel bed which are occupied by stones, boulders, and pebbles of some size, and argue on much the same lines as to the conditions which have formerly existed there.

In 1879 the petrology of the English Channel was first seriously attacked. MR. A. R. HUNT then published in the *Transactions of the Devonshire Association* a paper "On a Block of Granite from the Salcombe Fishing Grounds." This was followed in 1880, 1881, 1883, 1885, and 1889 by five papers entitled, "Notes on the Submarine Geology of the English Channel off the South Coast of Devon." And, in 1896, the same author added later information in his paper on

"West Country Geological Problems," published in the same Transactions. It is noteworthy that MR. HUNT was on the track of a shore problem when his attention was thereby directed to the large boulders occasionally trawled by the fishermen off the south coast of Devon, and it is to these boulders that he confines his work. None the less he stands the first to really approach the matter from the point of modern petrology.

Meanwhile, in 1886, the late R. N. WORTH had taken up the question on very similar lines, and in the *Quarterly Journal of the Geological Society*, in August of that year, he reported the existence of a submarine Triassic outlier off the Lizard; in a subsequent paper, in the *Transactions of the Royal Cornwall Geological Society*, he dealt with a similar discovery off the Dodman.

Here the matter rested until, in 1895, DR. ALLEN commenced an investigation into the fauna and bottom-deposits near the thirty-fathom line from the Eddystone grounds to Start Point. In the course of this work numerous samples of the bottom-deposits were taken, and in vol. v, no. 4, of this journal will be found, incorporated in Dr. Allen's paper, some notes on these. The geologic results were subsequently dealt with at greater length by the present writer in the *Transactions of the Devonshire Association*, 1899, xxxi. pp. 356–75 ("The Bottom-Deposits of the English Channel from the Eddystone to Start Point, near the Thirty-Fathom Line"). Since 1899 the inshore grounds nearer Plymouth have also been subjected to an examination on similar lines, and additional geological information obtained which has not hitherto been published.

In the present paper it is intended to incorporate the whole of the previous results with the work done in 1906, of which latter an account is given by Mr. Crawshay in the preceding pages. By Mr. A. R. Hunt's kind consent an abstract of his petrographic work is added by way of an appendix, which, with other short appendices, will bring together the whole of our present knowledge of the geology and petrology of the western part of the English Channel.

Mr. Crawshay's long line of dredgings, extending to a point near 50 miles S. $16\frac{1}{2}°$ W. from the Eddystone, and Mr. Hunt's specimens, which reach 43 miles E. of the Eddystone, between them cover a large area; while to the westward for a distance of 36 miles we have the records of the late R. N. Worth. The difficulties which exist where no field work is possible are naturally considerable, but, as the writer has endeavoured to show elsewhere, very definite results, within certain limits, may be obtained by an inquiry of this kind. Other usual observations being barred, lithology becomes of the utmost importance,

and the microscope invaluable, since much of the minuter evidence afforded by a rock is as direct and positive as that on a large scale. It has been impossible to microscopically examine every variety found, but one hundred sections in all have been prepared, and it is hoped that most of the rocks may safely be grouped around those thus represented.

Before entering upon detail, it may be well to pass in review the manner in which the problem has been attacked by the various investigators. AUSTEN used both sounding-lead and dredge, he differentiated the textures of the deposits, giving such statements as that the gravel was of the size of almonds, beans, olives, walnuts, or the ground was stony, or large angular and rounded blocks occurred; he mentions flint, granite, black granite, tin-stone, serpentine, etc., but with no clearer lithological definition, and he records any shells of littoral species found in the deeps. His observations covered the whole Channel bed, but not closely, and extended from the Nymph Bank to near Dover.

DELESSE, with greater attempt at detailed location, but with less information as to the size of the constituents of gravels, maps out the Channel, discriminating between areas covered by 'argile,' 'craie,' 'sable,' 'sable riche en coquilles,' 'sable sur les roches pierreuses,' 'roches pierreuses,' 'roches en pierres désagregées,' and 'roches en pierres pourries ou décomposées.' He trusted to the sounding-lead for his samples, and none is recorded as coarser than gravel, while none which came from a greater depth than 28 metres is lithologically examined in detail; most were obtained very near the French coast.

HUNT chiefly derived his material from the occasional boulders captured in fishermen's trawls off the south coast of Devon; the more part of these were decidedly heavy, ranging from about 3 to about 12 cwt. All were examined microscopically by modern methods.

R. N. WORTH was supplied with blocks and stones of some size which had become entangled in long lines or bolters; he, too, examined the rocks microscopically.

THE ASSOCIATION has conducted systematic dredgings and endeavoured to obtain fair samples of the bottom-deposits, including sands, gravels, pebbles, and small boulders. Its gear has not permitted the capture of the larger blocks which undoubtedly occur, but three of these have been traced which have been obtained by fishermen, and hand specimens taken. Where pebbles have been dredged, in the later work at least, these have been entirely depended on for information as to the lithology of the station; in the earlier work, where pebbles were scarce, the sand was examined in detail also. The superior facilities

which the Association enjoys advantages it greatly, but our debt to the earlier workers remains undiminished, and in many instances they have preserved evidence of great importance, which must otherwise have been lost.

PETROLOGY.

To avoid the confusion which might arise from the system of numbering the dredgings, whereby three distinct sets of samples have all been numbered from 1 onward, the following method has been adopted. Actual hand specimens from Dr. Allen's first dredgings are referred to by the reference which the slides bear in the writer's collection, similarly specimens from the second set of dredgings further inshore, this will always be found to be a double number, such as "356/1", with sometimes a letter added also. In those cases where sands only have been examined, all of which occur in Dr. Allen's dredgings alone, the station number already published in the Journal is used, prefixed by the letter "A." The most recent stations, of last year's work, have the letter "M" set before the number; and Mr. Hunt's own figures are used with the letter "H" prefixed. Mr. R. N. Worth's specimens bear a number prefixed to which is the letter "W."

Where more than one rock is described from a station small letters are added after the number, by which the various specimens are discriminated.

With reference to the dredgings taken last year, the rule has been adopted that if several varieties or specimens of one class rock have to be described, those are set first which are nearest the Eddystone, and of those at equal distance precedence is given to the more western.

Throughout, the abbreviation "Edd." represents the word Eddystone.

GRANITES AND ALLIED ROCKS.

A large number of specimens, generally distributed over the area examined, fall within the popular acceptation of the term '*Granite*,' but the greater part of these when submitted to microscopic examination must be transferred to the Quartz-diorites in consequence of the distinct preponderance of plagioclase felspars. Since it is impossible to be certain in which class to place many of the specimens on mere inspection, and it has been out of the question to section all, those as to which any doubt exists are hereafter collected under the head of '*Granitoid Rocks*.'

GRANITES.

Boulder. S.S.W. Start, 15 miles. Weight about 8 cwt.

A fine-grained white granite, with very uniformly disseminated black mica. The little felspars are bright and fresh, and the simple

twinning of orthoclase shows in almost every one. Some of the felspars are slightly tinted yellow by powdery decomposition products. The mica inclines to a reddish bronze lustre. The general structure of the rock is very uniform.

In the section a portion of the felspars is seen to be slightly clouded. The more part are orthoclase, but the orthoclase at places encloses small crystals of triclinic felspars, of which larger areas also occur. There is a tendency to zonal structure in some of the felspars, and there are a few very small areas of graphic structure. The quartz contains fairly numerous fluid inclusions with bubbles, some apparently empty or gas-filled cavities, and frequent hair-like microlites, probably apatite. Almost all the mica is brown and intensely pleochroic, but associated with this is a little which is colourless and shows no pleochroism. Apatite is present.

Boulder. S.W. by S. ½ S. Bolt Head, 19 miles. Weight 833 lbs.

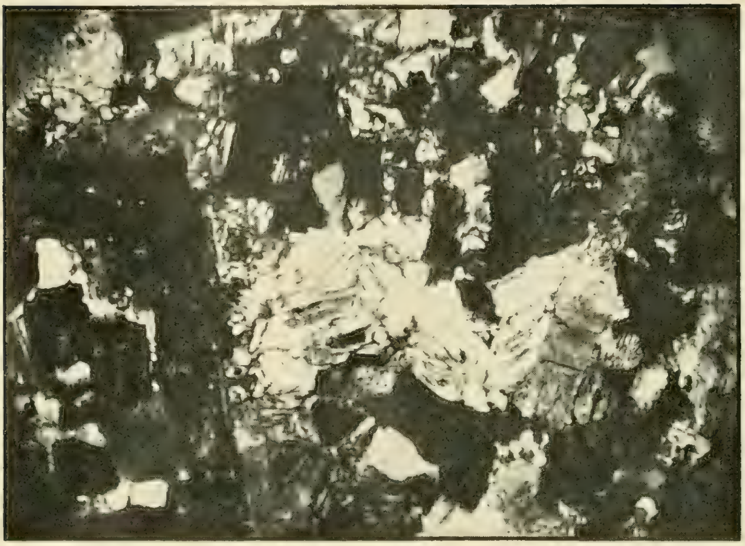
A coarse rock of granitic texture. The felspar gives bright cleavage surfaces, but is largely yellow-stained by dusty decomposition products; there are no good crystal outlines. Black mica occurs in patches of granular texture.

The large orthoclase areas are seen in section to be intergrown with plagioclase, narrow irregular and only approximately parallel strips of which penetrate the orthoclase; all the strips in each crystal extinguish together and in a different position to the main crystal, and all show lamellar twinning, the direction of which is constant throughout the crystal; thus the intergrowth gives rise to micro-perthite. Those felspars, the less numerous, which are clouded with decomposition products, all appear to be triclinic. The quartz presents numerous fluid inclusions, and in places is crowded with other inclusions which appear as a fine black dust; there are also small acicular microlites. The mica passes from olive-brown to dark green on rotation, but there is a little that is almost colourless.

M. 58b. S. 22° W. Edd., 39 miles.

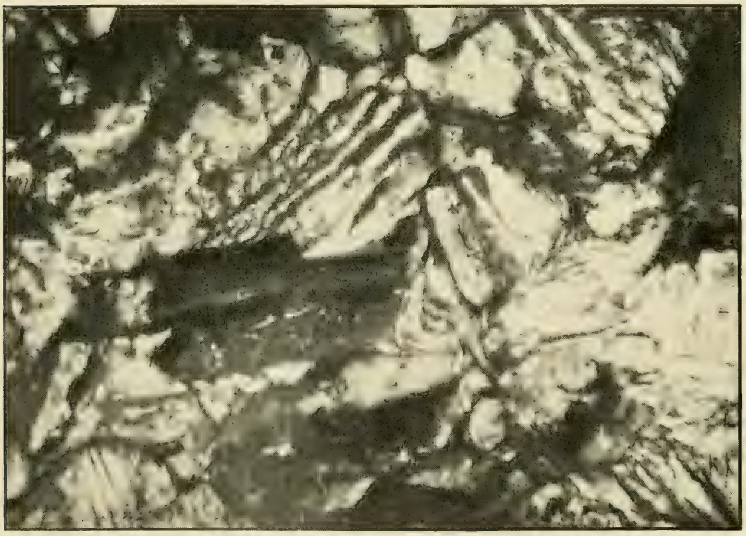
Medium textured granitic rock, pale flesh-coloured felspar, dark and light mica. Structure granitic. Felspars clouded brown. There are small patches of very well defined graphic structure, here the felspar is clearer. Multiple twinning can still be detected in places. Nearly half the felspar is still almost clear; none of this shows plagioclase twins. Much colourless widely biaxial mica. Quartz plentiful, crowded and lined by fluid inclusions, all with bubbles; many of these inclusions are of comparatively large size. There is a little apatite, and in one part of the slide a chloritic mineral fills the cracks in a felspar.

FIG. 1.



M. 11a. S. 26° W. Edd., 17·8 miles.
Micro-pegmatite.
Crossed nicols. × 29.

FIG. 2.



M. 11a. S. 26° W. Edd., 17·8 miles.
Micro-pegmatite.
Crossed nicols. × 97½.

To face p. 123.

MICRO-PEGMATITE.

M. 11a. S. 26° W. Edd., 17·8 miles.

Red granitoid rock of fine grain, black mica.

Many felspars clouded entirely with red-brown decomposition products. Others, but fewer, almost clear. Some crystals are practically opaque in the centre, clear outside, with successive narrow zones of brown. Graphic structure is well developed; often where it has invaded a felspar crystal there will be included in it small perfect crystals free from this structure. Repeated twinning is rather rare. The fluid inclusions in the quartz are very small, most have bubbles, and extremely rarely a cubic crystal occurs. There is a little dark green biotite and some ilmenite. The graphic structure is the great feature of the slide. (Plate VI, figs. 1 and 2.)

APLITE.

M. 11c. S. 26° W. Edd., 17·8 miles.

A fine grained red granular rock with nests of schorl visible in the hand specimen.

An aplite consisting of quartz and felspar only, except for the tourmaline above mentioned. Structure microgranitic. Felspar red, and somewhat clouded in parts, mainly orthoclase, but plagioclase present. The quartz contains numerous and rather large fluid inclusions, nearly all with bubbles, many with crystal inclusions. Most of the tourmaline is indigo in colour, but some small crystals give brown to blue pleochroism.

This might be a type rock from Dartmoor. It can be matched *in situ* in the valley of the Tavy toward and below the lower end of Tavy Cleave, and a precisely similar rock was found as a small boulder resting on the rock bed some hundred feet below the surface of the mud at Keyham Extension Works.

M. 27x. S. 19° W. Edd., 18·3 miles.

A schorlaceous aplite very similar to **M. 11c.**, but which has not been microscopically examined.

M. 24g. S. 24° W. Edd., 22·5 miles.

Granular felsite of rich red colour.

The section exhibits microgranitic structure. All the felspars are more or less clouded, a few considerably, and in some cases the ordinary optical properties are destroyed. Orthoclase distinctly predominates, but plagioclase twinning is not rare. The felspars show rounded outlines, marked in some instances by a narrow line of iron oxide, and flakes of hematite occur in some of the crystals. The quartz shows

fairly numerous fluid inclusions of very small size. No other mineral is present. The rock must be classed as an aplite.

Similar rocks to 24g are 34e, S. 28° W. Edd., 18·5 miles and 14e, S. 24° W. Edd., 20 miles.

FELSITES.

Under this heading are placed a number of rocks which fall readily into three groups, the first of which consists of two specimens, almost identical in character, and very familiar in appearance to any one who has an acquaintance with the Permian and Triassic rocks of Devon.

M. 27c. S. 19° W. Edd., 18·3 miles.

Compact red-purple felsite, with light porphyritic felspars and black mica. Fracture trachytic. Has all the appearance of one of the new red felsites.

M. 41a. S. 36½° W. Edd., 26·6 miles.

Felsite, texture trachytic, colour red-brown, small dull white porphyritic felspars, and a little black mica. Cryptocrystalline ground-mass. A few idiomorphic felspars. A few porphyritic quartz crystals with corroded outlines. Well developed, highly pleochroic brown mica. The ground-mass contains numerous microlites, also many small felspars outlined in or largely replaced by hematite. Flakes of hematite are very numerous. A typical red-rock felsite.

The specimens placed in the second group form a series, commencing at the Hand Deeps and terminating M. 62, 46·4 miles S. 25° W. from the Eddystone. Of these the northernmost example has been subject to considerable mineral alteration; the southernmost is the most fresh, and in the latter the porphyritic constituents are more prominent than in any other. The northernmost is probably alone in that it contains mica. All are strongly reminiscent of rocks elsewhere associated with the Permian and Trias.

354/3d. Slopes of Hand Deeps.

A grey rock, with a slight shade of green and small purple spots. Small felspars appear, colour buff, all somewhat decomposed. At places the tint of this rock varies to yellow and to purple. There are minute black specks of a hard mineral, and calcite is developed on joint faces.

Microscopically the ground-mass is seen to be crypto-crystalline with much minute calcite, areas of which mineral also occur. Small felspars are scattered through this mass, and are about uniformly divided between orthoclase and plagioclase. Quartz occurs in small patches of interlocked granules. Mica is now almost entirely replaced by pseudomorphs in limonite and magnetite.

M. 36e. S. 37° W. Edd., 17·5 miles.

Sub-conchoidal fracture. A dull purple rock, with parts more drab in colour, flesh-tinted felspars in a horny matrix.

M. 35d. S. 32° W. Edd., 18 miles.

Grey, with warm tinge, purple mottling, sub-conchoidal fracture, minute flesh-tinted felspars, mostly much decomposed.

M. 20a. S. 25° W. Edd., 20·5 miles.

Compact rock, very like 354/3d. in general appearance, but without the small black grains and the calcite. Rather harder than that rock. Grey in colour with warm tinge. Small flesh-coloured felspars, many of which are decomposed.

M. 21b. S. 25° W. Edd., 21·2 miles.

Compact light grey-drab felsite, red mottling, porphyritic quartz.

Crypto-crystalline felsitic ground-mass, in which porphyritic quartz is freely developed; the crystals, although rounded at the angles and at places invaded by the felsitic matter, are largely bounded by straight lines. Minute fluid inclusions are not uncommon, but comparatively the quartz is clear. The felspars are almost formless and ill differentiated from the ground-mass; micro-perthite is indicated in some individuals. There is a small yellow patch of some granular mineral showing brilliant colours between crossed nicols. This same mineral is also sometimes associated with the dusty, somewhat dendritic red oxide of iron which gives the rock its mottling.

M. 62c. S. 25° W. Edd., 46·4 miles.

A green-grey compact rock, with much quartz and felspar irregularly distributed. The felspar is pink. The porphyritic constituents more prominent than in any of the preceding. Calcite is freely developed on joint faces.

The third group would appear to bear a close relation to the granites which form a prominent feature of the lithology of parts of this area. In this respect they probably stand much as the very hard India-red felsite so freely found on the Hallsands Beach does to the granites of Dartmoor. All are horny in texture and have a sub-conchoidal fracture.

M. 12f. S. 26° W. Edd., 17·8 miles.

No detailed notes taken of this rock.

M. 72d. S. 23° W. Edd., 19 miles.

India-red, compact felsite, occasional small red felspars.

M. 9a. S. 31° W. Edd., 21·7 miles.

Red felsite. Green porphyritic felspars, compact texture.

Ground-mass crypto-crystalline. Felspars much decomposed, the green

shade being due to a secondary mineral. This traverses the crystals along irregular cracks, and sometimes extends from them a short way into the ground-mass, continuing the line of the crack; it is also generally distributed in the crystal. The less altered felspar is pale red in colour. The green mineral is often fibrous and sometimes granular, it has a high double refraction; apparently we are dealing with epidote. Quartz crystals, somewhat corroded, are rather common, and show a fair number of very minute fluid inclusions with bubbles.

Titanic iron ore is scattered in small grains throughout the slide, but much more freely developed and in larger forms at some places where associated with the green decomposition product above referred to. All the ilmenite is much altered and the smaller crystals are now entirely leucoxene. Apatite occurs, and two much altered areas were once apparently mica.

QUARTZ-DIORITES, DIORITES, DOLERITES, AND DIABASE.

It is possible that exception may be taken to the manner in which some specimens have been placed in the subdivisions of this group. But the erection and maintenance of hard and fast boundaries, where none such exist in nature, invariably brings the element of personal judgment into play, and in most cases it will be found that ample detail is given to enable the reader to reclassify the specimens to his individual preferences.

No pretence can be made that any more than a few, and those the most representative, of the rocks in this group are here given.

QUARTZ-DIORITE.

M. 11, l. S. 26° W. Edd., 17·8 miles.

Brownish granitoid rock of medium grain. Texture granitic. Felspars clouded light brown, but wherever the structure is not masked by this show very closely repeated twinning. Outside the better defined crystals there is some clearer and probably secondary felspar. Quartz plentiful, traversed by streams of fluid inclusions in two or more directions. The cracks in quartz and felspars alike are iron-stained. Hornblende in short, well-marked, prism forms, pleochroism light brown to rich green, two twinned crystals. Ilmenite occurs both in hornblende and in felspars. A few minute crystals of apatite. Quartz hornblende diorite.

M. 72e. S. 23° W. Edd., 19 miles.

Pale green rock, with close texture and fine grain, black or very dark green spots of small size.

Micro-granitic structure. The minerals are felspar, quartz, hornblende, magnetite, mica, and augite. The felspars are clear in patches,

but otherwise much clouded, and all are plagioclases. The quartz contains small and moderately numerous fluid inclusions. Hornblende occurs in two forms; some of it is almost certainly an original mineral, and shows good basal sections, with inclusions, however, of other minerals. Elsewhere the hornblende is more fibrous. The mica has suffered considerable change, if I am right in so identifying a very doubtful mineral, and very little unaltered augite remains. Might almost equally well be classed as a quartz aphanite.

M. 9e. S. 31° W. Edd., 21·7 miles.

Dark grey crystalline rock of rather fine texture. Small felspars of irregular shape and slightly greenish tint, small quartz granules, very clear and bright.

The felspars are plagioclase, much clouded in the centre, quite clear around the margins when crystal outline is shown. Some have obviously been broken. In the felspars occur very numerous small prisms and acicular forms of a clear mineral which may be zoisite. Some felspars show an irregular zone of decomposition products a little within the margin. Most of the quartz areas break down in some part to a mosaic of interlocked granules. The quartz contains fluid inclusions. Strain shadows show in both quartz and felspar. Hornblende, chiefly of an olive shade, is freely developed, much is markedly uralitic. A little chlorite occurs. There is some apatite, and a little ilmenite.

M. 9r. (Same location as last.)

Fine-grained grey rock, felspar and hornblende visible.

Plagioclase felspar, somewhat clouded, occasionally achieving good crystal boundaries, and with a marked tendency to zoning from secondary growth, clearer from decomposition than the centres. Repeated twins somewhat frequent. Minute epidote has been freely developed in many of the felspars, and granules of a mineral which is apparently epidote. Fibrous hornblende is a prominent constituent, occurring in large patches, spreading and extending between the felspar areas; principally it is of a green colour with a tendency to blue; here and there brown and olive shades occur, especially in the interior of some of the larger patches. Quartz is fairly plentiful, with numerous small fluid inclusions, most with bubbles, and a few apparently include very small cubic crystals. Some apatite.

M. 19a. S. 28° W. Edd., 23·3 miles.

Dark greenish grey, granular crystalline. Felspars small and slightly green in tint. Fine grain. Texture micro-granitic. The felspars a good deal clouded with pale brown decomposition products, but with frequent clear patches. Some crystals with characteristic

microcline twinning. By far the greater part is probably, however, oligoclase. Quartz abundant, in large areas of compound structure. The quartz is traversed by narrow streams of fluid inclusions, and contains small rod-shaped crystals, apparently of apatite. Both massive and actinolitic hornblende occur. The pleochroism of the former is pale yellow-brown, dark olive-green. At places a vivid chlorite replaces some of the hornblende. The quartz is slightly iron-stained in some of the cracks. Quartz hornblende diorite.

Four rocks apparently similar to the group **M. 9e.**, **M. 9r.**, and **M. 19a.**, are—

(1) **M. 11b. S. 26° W. Edd., 17·8 miles.**
Dark grey granitoid rock of fine grain.

(2) **M. 11k.**
A finer texture of M. 11b.

(3) **M. 9q.**
Dark grey, fine grained, felspars greenish.

(4) **M. 50a. S. 16° W. Edd., 30·9 miles.**
Grey crystalline rock, minutely granular fracture, rather small white felspars somewhat widely scattered.

M. 18a. S. 29° W. Edd., 23·4 miles.

Structure granitic, medium texture, colour grey.

Somewhat clouded felspar, apparently plagioclase. Graphic structure in many crystals. Quartz traversed by broad streams of fluid inclusions, some with bubbles; hair-like microlites also occur, and some larger, recognizable, apatite. There are two micas, the one colourless, the other brown and intensely pleochroic, the extreme tint being a very dark bronze green. Quartz mica diorite.

M. 58a. S. 22° W. Edd., 39 miles.

Black and grey granitoid rock, medium grain.

Granitic texture. Felspars in the main clear, but here and there clouded with decomposition products. All apparently plagioclase and probably oligoclase. The quartz clear, with small fluid inclusions and, at places, hair-like microliths. Brown and olive-brown mica, strongly pleochroic. Green and olive hornblende, always associated with mica, but on the whole in less quantity. The hornblende and mica interpenetrate. A fair amount of apatite is present.

The rock must be classed as a quartz-diorite, with hornblende as well as mica present.

M. 80d. S. 16½° W. Edd., 48·9 miles.

Fine-grained brown granitoid rock, with black mica, texture granitic.

Felspar much altered and crowded with brown decomposition pro-

ducts. A few crystals appear zoned, some still show repeated twinning. Much quartz, in which fluid inclusions are common; a majority of these inclusions have bubbles. Brown mica. Apatite. Some iron-staining. Quartz mica diorite.

DIORITE

M. 12d. S. 26° W. Edd., 17·8 miles.

A striking looking rock by reason of the lustre of its constituent minerals. Very dark in colour, consisting as it does of a black mineral in prismatic form, and a clear felspar. Some of the little prisms of the black mineral are as much as 3 mm. in length.

The rock consists of a clear labradorite, in which, however, calcite granules are developed here and there along cracks; and a green monoclinic pyroxene, ægirine, in which a very marked schiller structure has been set up, the microlites being of a dark brown. Minute crystals of pyroxene appear in the felspars. Irregular patches of an iron oxide, apparently magnetite, are common.

M. 35b. S. 32° W. Edd., 18 miles.

A fine grained, dark grey, granular rock with much mica. Besides the dark mica there is obviously a lighter mineral, and the two are very uniformly admixed.

The section shows this rock to be a mica-diorite. Rich brown mica occurs freely in irregular plates, and felspar in mosaic. A minority of the felspar granules are striated, a very few show decomposition products. An occasional crystal of apatite is present and a fair amount of titanic iron ore in small grains. The general appearance of the rock is very fresh.

A similar rock to **M 35b.** is

M. 79a. S. 16° W. Edd., 48·7 miles.

Dark grey, close textured, much mica in small form.

M. 9s. S. 31° W. Edd., 21·7 miles.

A dark coloured rock, the exterior of which shows large lustrous black hornblende and dark drab and brown felspar. Fracture very uneven and texture coarse.

The felspars in this rock are now almost indistinguishable as such, an occasional very small patch showing repeated twinning being all that remains unaltered; for the rest they have given place to a granular and fibrous mineral of high refraction and double refraction, and apparently colourless, although the larger grains may have a palest shade of green. The rest of the slide is occupied by fibrous pale green hornblende. Ilmenite is common. The structure ophitic.

DOLERITE.

M. 14e. S. 27° W. Edd., 20·3 miles.

A fine-grained even-textured rock of a distinct green colour. Some iron pyrites show in the hand specimen. Numerous lath-shaped felspar microlites with irregular terminations, all quite fresh and clear. Pale bluish-green fibrous hornblende is quite the most prominent constituent of the rock; there is no general direction pursued by its fibres. Scattered closely throughout the section are very irregular grains of a minutely granular pale brown mineral of strong double refraction when examined with high powers and strong light. Dirty white by reflected light, this is probably leucoxene.

Curious little streams of (?) magnetite occur rather frequently, in forms suggesting that they are reminiscent of some original prismatic mineral.

M. 16b. S. 29° W. Edd., 20·9 miles.

Pale green minutely granular rock.

A slide of confused texture. Fibrous green hornblende. Felspar with a tendency to lath-shaped sections. Apparently no quartz. Grain very fine.

M. 21e. S. 25. W. Edd., 21·7 miles.

A close-textured grey rock, looks much like a grit.

The most prominent feature in the section is the abundance of pale yellowish-green acicular or fibrous mineral in diverging bundles, which often have the appearance of having been drawn together at the middle. Here and there almost colourless, at other places this mineral takes a blue-green tint, and it is almost certainly actinolite. These bundles are largely set in a crypto-crystalline ground-mass, which is freely invaded by shorter prisms of actinolite. There are also felspar crystals of irregular outline, some certainly plagioclase, some possibly orthoclase, and micro-porphyritic quartz is about as frequent as the felspar. There is a considerable sprinkling of grains of titanic iron ore.

M. 80c. S. 16½° W. Edd., 48·9 miles.

Clouded white felspars, lath-shaped in part, in part conforming to the interspaces between the augites which constitute the more part of the rock. Portions of the felspars are still quite clear. The augite is in the main quite fresh, but traces of chloritic products occur. Characteristic patches of ilmenite.

DIABASE.

M. 27a. S. 19° W. Edd., 18·3 miles.

Compact dark grey rock, green felspar and hornblende. Augite, hornblende, chlorite, plagioclase, leucoxene, quartz. The augite, pale

brown, apparently existed in ophitic form; it is now almost entirely replaced by hornblende. The hornblende is chiefly pale green, with a slight blue shade and orange-brown tints along cracks and cleavages. The titanic iron ore is entirely associated with the hornblende, and is present in large forms and branching growths. Chlorite occurs in fairly large areas, and exhibits marked pleochroism from pale brown pink to pale bluish green. The felspars are pale pink, rather fresh in appearance, but sometimes traversed along cleavages by chlorite; they have a tendency to elongated parallelogram section. Quartz shows good crystal outline.

M. 14v. S. 24° W. Edd., 20 miles.

A small hard pebble, distinctly green in colour, and having small somewhat vesicular looking cavities on the surface.

In section, seen to be a network of small lath-shaped felspars set in a grey and green ground-mass. Chlorite is disseminated throughout the slide, and the larger patches, which are not infrequent, are evidently after augite, as they are associated with unaltered remnants of the latter mineral. Calcite occurs, not only mingled with the ground-mass, but also in larger patches; the solution of these has probably left the cavities on the surface of the pebble. There are two or three recognizable crystals of ilmenite and scattered black grains that are either this mineral or magnetite.

M. 15c. S. 27° W. Edd., 20·3 miles.

Greenish hornblendic rock.

Large patches of very pale hornblende. Between these a fibro-granular ground-mass of low double refraction, prismatic and basal sections of zoisite of sufficient size for discrimination occur rather freely. Some iron ore. What other minerals may be present in minute forms cannot be determined.

Zoisite-amphibolite.

M. 22c. S. 25° W. Edd., 21·9 miles.

Dark green rock, massive hornblende.

Shows a very little felspar, and a few patches of augite. In the rest it consists of reedy hornblende of very varying tint, from almost colourless to olive-brown and blue-green, all in light shades.

GRANITOID ROCKS

M. 31. S. 25° W. Edd., 15 miles.

Granitic texture. Brown and black, ditto brown.

Felsitic. Brown, fine-grained, granular.

M. 36. S. 37° W. Edd., 17·5 miles.

Granitic texture. **f.** Medium grain, white felspar, black mica.

g. Fine grain, pink, black specks.

Felsitic texture. **b.** Brown, granular.

M. 33. S. 25° W. Edd., 17·5 miles.

Diorite.

M. 11, M. 12, M. 13. S. 26° W. Edd., 17·8 miles.

M. 11. *Granitic texture.* **g.** Fine-grained brown, black mica.

M. 12. Hornblende Diorite.

Granitic texture. Red with abundance of mica. Brown of fine grain. Brown of medium grain. Grey.

M. 35. S. 32° W. Edd., 18 miles.

Granitic texture. **f.** Brown.

M. 27. S. 19° W. Edd., 18·3 miles.

Granitic texture. Pale grey.

M. 26. S. 20° W., 18·4 miles.

Two quartz-hornblende-diorite pebbles.

M. 34. S. 28° W. Edd., 18·5 miles.

Felsitic texture. **g.** Brown, fine granular.

M. 72. S. 23° W. Edd., 19·0 miles.

Granitic texture. Medium grain, grey and brown, brown mica. Brown. Red with black mica.

Felsitic texture. **c.** Porcellanous cream-coloured.

M. 14. S. 24° W. Edd., 20 miles.

Granitic texture. **k.** Red medium grain, and several other varieties.

Felsitic texture. **t.** Close-grained buff.

M. 15. S. 27° W. Edd., 20·3 miles.

Granitic texture. Coarse-grained, white felspar, yellow-stained, black mica, much like boulder from S.W. by S. ½ S. Bolt Head, 19 miles.

Fine-grained grey, brown and silvery mica.

Brown with white mica.

M. 20. S. 25° W. Edd., 20·5 miles.

Granitic texture. **f.** Black and white, rather coarse, some hornblende.

e. Black and buff, fine grained, (?) some hornblende.

M. 16. S. 29° W. Edd., 20·9 miles.

Granitic texture. Distinctly granitic in appearance, flesh-coloured felspars, orthoclase twins, quartz.

Grey and brown, fine grained.

M. 21. S. 25° W. Edd., 21·2 miles.

A few grey granitic rocks.

M. 30. S. 21° W. Edd., 21·5 miles.

Granitic texture. **d.** Coarse, pale cream-coloured, dark mica.

M. 9. S. 31° W. Edd., 21·7 miles.

Granitic texture. **l.** Medium grain, red felspars.

m. Medium grain, buff felspars.

r. Fine-grained grey.

Medium grain, brown and black.

M. 40. S. 38° W. Edd., 21·7 miles.

Granitic texture. Brown, medium grain.

Felsitic texture. Brown, granular.

Greenish grey.

M. 22. S. 25° W. Edd., 21·9 miles.

Granitic texture. **b.** Buff and brown felspar, black hornblende, medium texture.

M. 24. S. 24° W. Edd., 22·5 miles.

Felsitic texture. **c.** Pale grey, compact, white mica. Red.

M. 25. S. 24° W. Edd., 23 miles.

Granitic texture. **b.** Brownish, fine grained, (?) hornblende.

M. 19. S. 28° W. Edd., 23·3 miles.

Granitic texture. **b.** Dark grey, fine grained, much dark mica.

M. 18. S. 29° W. Edd., 23·4 miles.

Granitic texture. Brown and grey, medium grain, pale grey felspars.

M. 43. S. 21° W. Edd., 28·8 miles.

Felsitic texture. Brown-grey, granular.

M. 77. S. 11° W. Edd., 38·8 miles.

Granitic texture. Brown, very fine grain.

Light brown, fine grain, black mica.

M. 58. S. 22° W. Edd., 39 miles.

Granitic texture. The granitoid rocks occur in rather large pebbles, almost small boulders.

Grey, rather coarse, clear felspars, black mica.

Grey, rather fine, clear felspars, black mica.

M. 62. S. 25° W. Edd., 46·4 miles.

Felsitic texture. **c.** Compact, greenish grey, with pink felspars and porphyritic quartz.

d. A somewhat similar rock, more granular, felspars white, some hornblende.

Also, pink, saccharine texture.

M. 80. S. 16½° W. Edd., 48·9 miles.

Granitic texture. Brown-grey, fine-grained, black mica.

Felsitic texture. Light brown-grey, black mica, apparently a variant of above.

All the above granitoid rocks are described from megascopic examination only, and the list is inserted chiefly in order to point out the localities in which this class of material has been found. To adequately deal with all the varieties a great number of sections would have been required, but probably those which have been microscopically examined give a fair general idea of the whole.

SCHORL ROCK.

Rocks consisting of tourmaline and quartz; placed here, although undoubtedly in a sense metamorphic, on account of their usual association with granite.

356/4a. W. ¼ S. Bolt Head, 4¾ miles.

A rather small pebble.

This rock consists of quartz and tourmaline. Much of the quartz is secondary; in part it forms a mosaic, in parts it extends from original crystals with which its crystal axis corresponds. The primary quartz contains fluid inclusions with bubbles, the bubble in many instances occupying more space than the fluid; these inclusions are very numerous and rather large. The secondary quartz contains few and very small fluid inclusions. Acicular schorl is scattered throughout the slide, sometimes in almost fibrous radial bunches, at others in slender, well-defined prisms, radially or otherwise arranged; there is also some more massive schorl. The colour is chiefly light blue to rich blue, but blue-green occurs, and occasionally olive-brown.

M. 31a. S. 25° W. Edd., 15 miles.

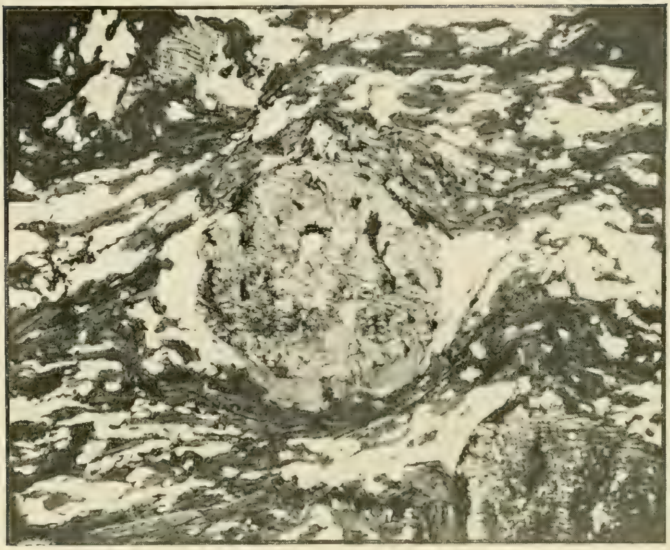
A schorl rock of Dartmoor type.

Ground-mass a quartz mosaic. The quartz contains many fluid inclusions, some of which, in addition to a bubble, have also cubic crystals in the fluid. These cubic crystals are, in fact, very common. The slide is crowded with granular tourmaline, chiefly a very dark brown colour, almost opaque, but a few grains are blue-green.

M. 31g.

Schorl rock. The general ground of a brown shade, an intimate mixture of rather pale brown tourmaline and quartz. Frequent areas of quartz partially invaded by acicular tourmaline. Some cracks are also filled by quartz. The quartz areas all present a mosaic, in which some grains contain many more fluid inclusions with bubbles

Fig. 1.



354/1. N.W. by N. (mag.) Edd., $\frac{1}{2}$ mile.
Hornblende gneiss, with garnets.
Ordinary light. $\times 14\frac{1}{2}$.

Fig. 2.

M. 62a. S. 25° W. Edd., 46·4 miles.
Crushed plagioclase felspar in chlorite schist.
Crossed nicols. $\times 29$.

To face p. 135.

than do others. Small cubic crystals are not infrequent in these inclusions.

Schorl rock also occurs at **36a, S. 54° W. Edd., 17·5 miles; 72, S. 23° W. Edd., 19 miles; 14f, S. 41° W. Edd., 20 miles.**

ANDESITES.

354/4b. 6½ miles W. from Rame Head.

Strictly speaking a felsite. Red-brown felsitic ground-mass, with porphyritic orthoclase, quartz, and dark mica. One of several pieces here dredged, with every indication of being practically *in situ*. Is much like the andesitic felsite of Withnoe, but lacks the flow structure sometimes present in the latter. The similarity of the specimens to many, however, which have been collected at Withnoe practically amounts to identity. Thus to the Cawsand mass and the two near Withnoe we have to add another, and a submarine, patch of igneous rock of the New Red Sandstone period. Apparently this exposure is of some considerable area. A conglomerate containing large fragments of this rock was taken in the same dredging.

M. 15a. S. 27° W. Edd., 20·3 miles.

Brownish-grey trachytic rock.

Well-marked flow structure. Ground-mass a devitrified glass (palagonite). Some augite developed in rare crystals and crystalline areas. Flakes of very dark brown mica rather frequent. Lines and microdendritic growths of iron ore (?) hematite. Occasional patches of calcite.

M. 15. Also yielded a more red variety of the above.

GNEISS.

Some latitude must be allowed in any classification which attempts to discriminate Gneiss from Schist in this area. If anything, the writer leans toward identification as the former in doubtful cases.

354/1. N.W. by N. Edd., ½ mile.

A large stone or small boulder, angular with freshly fractured surface. A grey-green foliated rock with plates of brown mica and numerous garnets up to 1·75 mm. in diameter. Quartz fills thin joints at right angles to the planes of foliation. The mica is so developed as to give to the rock an easy cleavage.

The pale-pink garnets are a characteristic feature; these are much cracked, and around them bend the less resisting minerals. There is much blue-green actinolitic hornblende, the blades of which all approximately conform to one direction. Mica is in much less quantity than would appear from the hand specimen; it is intensely pleochroic, from pale straw-colour to dark cinnamon-brown; its occurrence is practically limited to the neighbourhood of the garnets.

Touching and partially enveloping the garnets is a certain amount of chlorite. Water-clear felspar in mosaic form fills all interspaces; it appears to be albite, and inclusions of apatite are frequent. There seem to be some rare fragments of pale brown-augite. (Plate VII, fig. 1.)

354/3f. Hand Deeps.

A schistose or foliated rock, dark steel-grey in colour, and highly lustrous from the abundance of pale mica. Rare eyes of red felspar occur.

The section does not pass through any of the felspar eyes. There is a distinct banded structure: bands in which hornblende predominates, bands consisting almost entirely of white mica, bands of felspar mosaic. But in every layer there is some slight admixture of the other minerals. The hornblende is both uralitic and actinolitic with very distinct indigo tint here and there. It is not entirely free from chlorite. The mica appears perfectly fresh and shows no trace of pleochroism. Both hornblende and mica exhibit a parallelism of arrangement. The felspar is apparently albite, quite clear, with apparently a casual grain of quartz. Grains of sphene are not uncommon.

355/1. West side of East Rutts.

A brown stained schistose or gneissic rock, exhibiting much contortion.

No part of the slide is entirely free from iron stain. Contorted bands of limonite traverse it, and these appear to have been developed at the expense of mica, bleached residual blades of which are associated with it. All the mica is much bent. Parallel with, and touching the limonite, are narrow interrupted bands of calcite. The general ground-mass is a mosaic of slightly stained clear minerals, and apparently consists of albite (?) and quartz in about equal proportions, the quartz showing fluid inclusions with bubbles, and the albite being rather frequently twinned.

M. 36p. S. 37° W. Edd., 17·5 miles.

A mica schist or gneiss, shows clear felspar, some in moderate-sized crystals, and mica which is in general rather silvery but in small patches dark bronze.

There are two orders of felspar, the one represented by slightly clouded crystals of irregular outline and exhibiting signs of crush, the other present in mosaic form. The repeated twinning of plagioclase appears almost constantly in the former, but not at all in the latter. And some few of the larger crystals extinguish differently in different zones, although there is no appearance of zonal structure except

between crossed nicols. The mosaic in places is of larger and irregular granules, in places of small granules of lenticular form the longer axes of which lie parallel to each other and form lines flowing round the crystals of the first order. The mica conforms in general direction to these same lines, it shows moderately strong pleochroism, and its face colours range from rich cinnamon-brown in basal planes to a rather pale olive-brown in sections perpendicular to these planes. A very little apatite is present.

M. 16a. S. 29° W. Edd., 20·9 miles.

Schistose rock. Dark grey and pale brown, lamination very clearly defined; fissile. Much dark grey mica on joint faces.

Structure schistose. Irregularly bounded felspar areas occasionally associated with quartz form "eyes," around which the other minerals are bent. These felspars are all much clouded; some are thickly set with microlites, but polysynthetic structure is clearly discernible in many instances. Most of the felspars are curiously isolated from their surroundings and have a rounded form, as though due to friction. White mica is abundantly developed, forming streams in which the felspars appear as islands. Mingling with the mica is dull green hornblende in short blades and in grains. There are numerous long patches and irregular areas of quartz mosaic, the quartz containing some apparently fluid inclusions, prismatic microlites, the larger of which are seen to be hornblende, and rather frequent blades of the latter mineral. The mica does not appear to invade the quartz areas. Apatite is fairly plentiful. There is occasional staining by iron oxide, especially between the quartz grains and the blades of mica.

This rock is a gneiss, and has evidently been subjected to extreme pressure.

M. 9k. S. 31° W. Edd., 21·7 miles.

A grey gneiss.

Schistose structure well marked. Somewhat clouded felspars appear to form the only remaining original mineral. These show plagioclase twinning; some have been broken across with the development of a felspar mosaic along the line of fracture. There are two orders of mosaic structure, the one coarser and composed of a very clear mineral, the other much finer and containing minute hornblende and apparently zoisite. For the more part the large felspars are surrounded by this finer material, into which they have the appearance of having been driven. Ilmenite, hornblende, and zoisite mark out the planes of schistosity. The hornblende is almost entirely in minute blades and needles of a bright blue-green. Prisms of apatite are frequent in the

mosaic. Of this mosaic, which is probably almost all felspar, it should be noted that the coarser part is formed of entirely irregular interlocking granules; in the finer part the granules all appear lenticular, and their longer axes conform to the planes of schistosity.

From **M. 9** a coarse gneiss was also noted, and **M. 36q** is but a slight variant of **M. 36p.**

M. 25c. S. 24° W. Edd., 23 miles is a coarse gneiss with white opaque felspar and grey-green chlorite.

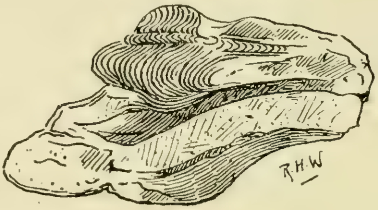
SCHISTS.

MICA SCHIST.

354/3/e. Hand Deeps.

A mica schist in which micaceous layers greatly contorted and convoluted alternate with granular layers of quartz and garnet. This rock has not been microscopically examined.

FIG. 1. Mica Schist from Hand Deeps.



M. 31f. S. 25° W. Edd., 15 miles.

A grey schist of very fine grain, traversed by rather broad lighter-coloured bands.

The section shows a distinctly foliated rock, the lighter parts are a clear quartz mosaic; I can detect no felspar; the quartz shows numerous fluid inclusions, some with very small bubbles. The darker parts appear to consist of a scaly mica of a yellow tint, associated with which is a little limonite and black granular matter which may be carbonaceous.

M. 11x. S. 26° W. Edd., 17·8 miles.

Micaceous schist, the planes of schistosity well marked by lustrous bronze mica, cleaves very perfectly.

The section shows, in addition to mica, a granular mosaic, which certainly in the main consists of quartz but also contains felspar, which latter can only be detected by its biaxial figure in convergent light. The quartz has, in the larger grains, fluid inclusions with bubbles. The mica is of a rich brown colour, but some few rather well-developed crystals are colourless. The basal sections show numerous acicular microlites, and also very dark brown patches, almost opaque, surrounding small crystals which are apparently zircon.

M. 9c. S. 31° W. Edd., 21·7 miles.

A schistose rock of light brownish-grey colour and rather pearly lustre; small darker spots mark an "eye" structure.

The general body of the rock is crypto-crystalline, polarizing in low tints. Streams of mica in minutest scales are developed in this ground-mass, especially near the "eyes," which largely consist of this mineral associated with a felspar mosaic in which some granules are large enough for identification. The basal planes of the mica follow one general direction throughout the slide. The dark colour of the "eyes" arises from irregular plates, aggregates of an olive-brown substance with moderate double refraction, but this may be somewhat masked by the colour.

M. 43a. S. 21° W. Edd., 28·8 miles.

A thin pebble of dark grey schist.

A minutely granular rock, consisting of quartz, felspar probably all plagioclase, white mica (sericite), epidote (?), chlorite, and traversed by a vein of calcite. Apatite is present in some quantity. The felspar granules freely exhibit the repeated twinning of plagioclase.

M. 20g. S. 25° W. Edd., 20·5 miles.

Closely resembles **M. 11x**, but the mica has a more decidedly bronze lustre. In both these rocks there are stray features of resemblance to the series from the immediate locality of the Eddystone.

M. 31c. S. 25° W. Edd., 15 miles.

Rather like a fine-grained granitoid rock, now stained brown by exposure, but fissile from the development of silvery mica along definite planes.

M. 36c. S. 37° W. Edd., 17·5 miles.

Largely quartz, but with possibly some felspar, silvery mica chiefly confined to the cleavage planes, which are stained pink with iron oxide. A very fissile rock.

CHLORITE SCHIST.

Off Stoke Point.

A silvery-green schist, consisting of vivid blue-green chlorite changed here and there to a dull orange, at which places it exhibits a moderate double refraction, and water-clear felspar in which no repeated twins are observable (the section is small). There is also apatite, and much of a granular dusty brown mineral, buff coloured by reflected light, leucoxene.

356/1. 4 to 5 miles S. ½ E. from Prawle Point.

A chlorite schist with bands of quartz one-eighth of an inch in width.

356/2. 3 miles S.S.E. ½ E. from Prawle Point.

A silvery grey chlorite schist with minutely wrinkled surfaces of chlorite precisely like the shore rocks. Much chlorite.

These last three specimens are practically identical with rocks to be found *in situ* on shore in the Start Point to Bolt Tail district. None of the specimens show signs of travel or wear.

M. 62a. S. 25° W. Edd., 46·4 miles.

A mixture of felspar and quartz, largely the former. Micro-mylonitic structure well developed and some of the felspars greatly deformed. One in especial, with well-marked plagioclase twinning, is much bent in reverse directions, is cracked, and finally at each end passes into mylonite. The slide is full of similar evidence of deformation. As a whole the felspar has a reddish tinge; some portions are crowded with microlites of high double refraction, probably calcite. Calcite is rather freely developed, filling interspaces and cracks. Chlorite plays a similar part, and the two are associated. In places the chlorite is thickly strewn with minute grains and blades of a feebly translucent brown mineral.

If the presence of original felspars is to be the criterion this rock should have been included among the gneisses. (Plate VII, fig. 2.)

HORNBLENDE SCHISTS WITH AUGITE.

356/4/b. W. ¼ S. Bolt Head, 4¾ miles.

A very compact dark greenish-grey schist with occasional small specks of pyrites.

The slide looks distinctly patchy, augite areas of brown tint, and granular augite. Much uralitic hornblende, blue in ordinary light, with a faint tinge of green, pleochroism brownish grey to blue-green. This mineral dominates the section. Much calcite, with a tendency to form broad bands. And, filling irregular interspaces, a mosaic of water-clear granules, containing both felspar and quartz. Calcite mingles with this mosaic. A little leucoxene occurs.

M. 80b. S. 16½° W. Edd., 48·9 miles.

Fine-grained dark grey rock; some pyrites.

Structure schistose. Marked in part by veins of secondary quartz in mosaic. The felspar is entirely clouded with decomposition products; it lies irregularly mingled with very pale green fibrous hornblende. The latter has apparently developed at the expense of a pale pink augite, of which a fair quantity remains; in turn the hornblende has here and there given place to chlorite. Irregular grains of a feebly translucent mineral, probably leucoxene, are plentiful, and have a distinct tendency to linear arrangement.

CALC SCHIST.

M. 14r. S. 24° W. Edd., 20 miles.

A compact rock with well-marked cleavage, the planes of which are not, however, closely set. Broken across the cleavage, the colour is a warm grey and the texture close and uniform. The cleavage planes show a somewhat pearly lustre and are stained in parts with red oxide of iron. The rock gives distinct effervescence with cold acid, with warm acid effervesces freely; fragments retain their form, however, but from the surface a few small quartz grains are set free.

The section shows numerous clear grains set in granular cement, with which, in places, is much red oxide of iron. Colourless mica (sericite) is rather sparingly developed, being more prominent on the cleavage planes. The clear grains are quartz, with the very rare exception of a felspar, and many show boundaries imposed upon them by the adjacent calcite and dolomite, which freely exhibits the rhombus form of larger or smaller dimensions. The granular cement consists, in fact, almost entirely of minutely crystalline dolomite and calcite, a high power being required to detect the crystal forms. A very large proportion of the quartz grains show secondary enlargement, the secondary quartz having the same crystal axes as the original grain. The boundary between the original and secondary is just such a dark line as occurs when a mineral of greater refractive index is enclosed in a mineral of less. Hair-like microlites are not uncommon in the primary quartz, but none pass over into the marginal secondary growth. In the loose powder obtained by treating this rock in hot acid I found one small crystal of tourmaline.

The fact that the rock retains its form after treatment with hot acid shows that neither the iron nor the dolomite are necessary cements, the secondary quartz being in itself sufficient.

Presumedly it is best to call the specimen a calcschist.

SERPENTINE.

M. 24h.

A small jet-black pebble with very smooth surface.

The section shows yellowish-green serpentine with "lattice" structure, traversed by roughly parallel streams of dense black material, which also occurs irregularly in cracks of varying direction, and more or less densely diffused in certain parts of the slide over areas which appear reminiscent of the original structure of the rock. The serpentine varies considerably in its depth of shade. At one point it is blue-green around the margin of a clear mineral, which appears possibly to be a plagioclase felspar.

The serpentine, some of which is colourless, splits up under crossed nicols into doubly refracting bands and isotropic portions.

The association of felspar with a massive serpentine is rare, but Professor Bonney has recorded an instance from the Lizard district.

This specimen acquires some value, despite its small size, since in HUNT'S series there occurs a serpentine boulder, **H. 6,** of 5 cwt.

QUARTZITES.

A number of quartzites, very similar to some in the Budleigh pebble-bed, have been dredged from a great many stations. Up to the present no fossils have been found in them. These rocks vary in colour, being purple, red, light red, buff, grey and white, and are associated with very hard grits which have not been sufficiently examined.

M. 80. S. 16½° W. Edd., 48·9 miles.

Purple quartzite, very compact in structure. Quartz grains, subangular and of very uniform size, fluid enclosures common. The cementing material silica with much iron oxide; this cement appears to be minutely granular. An occasional quartz grain shows hair-like microlites.

This may be taken as a type. Other *Purple Quartzites* were dredged at Stations **M. 31, M. 36, M. 13, M. 35, M. 27, M. 26, M. 34, M. 29, M. 14, M. 20, M. 9, M. 40, M. 22, M. 25, M. 43, M. 50, M. 67,** and **M. 80.**

Red quartzites from **M. 11, M. 72.**

Light red quartzites from **M. 13., M. 30.**

Buff quartzites from **M. 34, M. 20, M. 22, M. 41, M. 43.**

White quartzite from **M. 21.**

M. 11f. S. 26° W. Edd., 17·8 miles.

A grey grit.

A little mica appears in the section. The rock is practically a quartzite.

SEDIMENTARY ROCKS.

Under the heading of *sedimentary rocks* have been included all altered varieties, except such as may possibly have been fully metamorphosed to schists and quartzites.

CARBONIFEROUS AND EARLIER.

SANDSTONES AND GRITS.

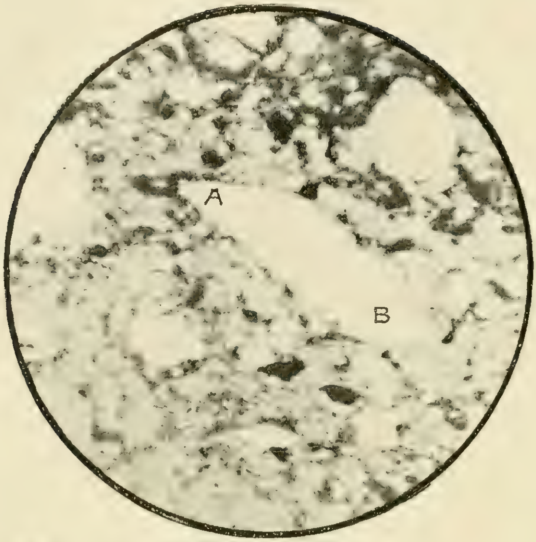
354/4k. 6½ miles W. from Rame Head.

A red micaceous grit, probably Devonian.

M. 9b. S. 31° W. Edd., 21·7 miles.

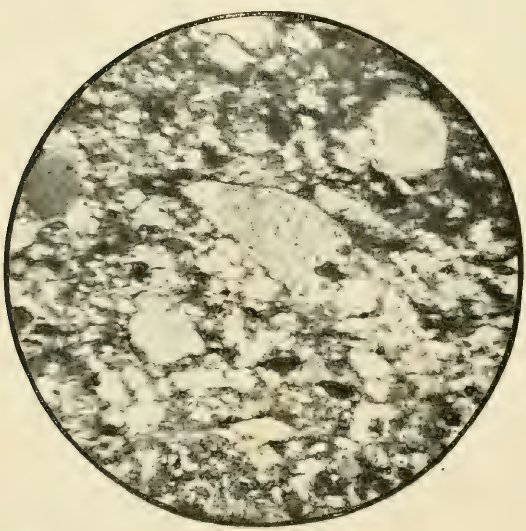
A light brown sandstone of flaggy structure, bedding marked by slight variations of tint. Possibly Devonian.

FIG. 1.



M. 9d. S. 31° W. Edd., 21·7 miles.
Grit, showing large grain, A–B.
Ordinary light. × 29.

FIG. 2.



M. 9d. S. 31° W. Edd., 21·7 miles.
Grit, showing compound structure of grain ; at end A striated felspar, at end B quartz mosaic.
Crossed nicols. × 29.

To face p. 143.

M. 9d.

A rather light grey rock, which appears to be a compact and very fine-grained grit; looks much like many grits of the Devonian age.

The microscope confirms preliminary examination; this rock is a grit of close texture. A considerable proportion of the granules are felspar, many showing repeated twins.

A number of the grains prove to be of compound structure, and are portions of quartz and felspar mosaics from some original schist or gneiss. Further than this, three of the larger grains are compounded of portions of felspars with bent striation and portions of quartz mosaic, being, in fact, derived microscopic specimens of gneiss. As bearing on the age of the rocks which have supplied the fragments. this slide is distinctly interesting. The interstitial matter largely consists of a rather pale chlorite in which occur rare blades of pale mica, There is some ilmenite, apparently detrital. (Plate VIII, figs. 1 and 2)

M. 11f. S. 26° W. Edd., 17·8 miles.

A fine grey grit slightly browned by exposure. Much like last in general appearance, and may well be of Devonian formation, already included as quartzite, the cement being apparently silica. The grains are sub-angular and include a few felspars. There are rather numerous grains of sphene, some irregular, some of the characteristic lozenge shape, all apparently derived.

Grits, not microscopically examined, were also taken at **M. 31, M. 27, M. 26, M. 14, M. 20, M. 16, M. 9, M. 40, M. 19, M. 41, M. 77,** and **M. 80.**

SLATES.

Unaltered slate was scarce, as might be expected from the fact that it would usually be associated with much harder material, and probably be soon destroyed.

M. 77a. S. 11° W. Edd., 38·8 miles.

Dark compact shale, a clay slate.

Under the microscope appears built up of minute grains of high double refraction. There are frequent traces of minute organisms, some possibly foraminifera. Some shell fragments still consist of carbonate of lime, and numerous forms of circular section are infilled with calcite.

M. 39. S. 38° W. Edd., 21·9 miles.

A decomposed slate.

ALTERED SLATES.

354/4j. 6½ miles W. from Rame Head.

A slate of Devonian type, evidently altered by the proximity of the andesite dyke which here occurs.

M. 14j. S. 24° W. Edd., 20 miles.

Almost black, a very compact rock with sub-conchoidal fracture, and lustre somewhat like a quartzite. The worn surface shows rather minute banded structure.

The same banded structure shows in section when examined by the unaided eye, but is less prominent under the microscope; this is a sedimentary rock altered by contact metamorphism. The general ground-mass is a crypto-crystalline substance, rising to a minute mosaic here and there, and probably having a complex mineral composition. Felspar almost certainly plays an important part. In this there occur small grey-clouded areas, presenting sections which are chiefly of somewhat ill-defined rhombus shape, and which in certain positions completely extinguish. One such area has a portion clear of dusty products, and this shows high double refraction in a bright and pure colour; other similar instances occur. The dusty material shows a tendency to arrange itself in zones and crosses, and from examination of a great number of these imperfect crystals there can be no doubt that the rock is crowded with andalusite in a condition bordering on the chiastolite form. For the rest, there is much small brown mica, and titanic iron ore, mostly in very small grains, is quite plentiful. Such a rock might easily arise from the metamorphism of a Devonian or Carboniferous slate by contact with a large boss of igneous material.

Altered slates, having the appearance of being baked by proximity to igneous rock, were also taken at the following stations, but have not been examined microscopically.

M. 11, M. 34, M. 72, M. 14, M. 15, M. 21 (common), **M. 24** (very common), **M. 17, M. 18.**

LIMESTONE.

M. 26b. S. 20° W. Edd., 18·4 miles.

A blue-grey limestone, veined and mottled with lighter calcite, much like some of the South Devon middle Devonian series. Consists almost entirely of irregular interosculating calcite patches, traversed by cracks filled with clear calcite. The calcite forms give indication of former organic remains, and at three places undoubted sections of madrepore occur. Around and between the boundaries of some of the calcite areas are very irregular and much folded lines of a granular black substance, apparently carbonaceous.

NEW RED SANDSTONE.

CONGLOMERATE.

354/3b. Hand Deeps.

A red conglomerate, certainly of the New Red Sandstone period.

Among the derived constituents are quartz grains of some size

showing mosaic structure and containing fluid inclusions with bubbles. Other grains of felspar mosaic precisely similar to that occurring in the neighbouring schists and gneisses. Blades of mica that may have been similarly derived. Quartzites, and fragments of highly cleaved slates, or very fine-grained schists.

Calcite or dolomite, probably the latter, is very prominent, filling the interspaces.

354/4b. 6½ miles W. from Rame Head.
Conglomerate with fragments of andesite.

SANDSTONE.

354/3c. Hand Deeps.
A coarse, red, micaceous sandstone.

354/2a. S.W. Edd., 2 miles.
Variegated sandstone, fine texture, red and grey.

354/2b.
Buff sandstone, almost salmon coloured.

354/2c.
Fine-grained compact red marly sandstone, sub-jaspideous.

M. 31. S. 25° W. Edd., 15 miles.
Red sandstone and buff sandstone.

M. 32. S. 25° W. Edd., 16·3 miles.
Red sandstone and yellow sandstone.

M. 10. S. 26° W. Edd., 17·8 miles.
Red sandstone.

M. 33. S. 25° W. Edd., 17·5 miles.
Red sandstone.

M. 34. S. 28° W. Edd., 18·5 miles.
Variegated, red and grey.

M. 27. S. 19° W. Edd., 18·3 miles.
Red sandstone and buff sandstone.

M. 26. S. 20° W. Edd., 18·4 miles.
Red sandstone.

M. 40. S. 38° W. Edd., 21·7 miles.
Variegated, red and grey.

M. 17. S. 28° W. Edd., 23·3 miles.
Red sandstone.

M. 19. S. 28° W. Edd., 23·3 miles.
Red sandstone in large angular blocks.

M. 18. S. 29° W. Edd., 23·4 miles.
Red sandstone.

M. 21g. S. 25° W. Edd., 21·2 miles.

(Not inserted in the above series because structurally different; all the above are of ordinary type.)

A compact rock with granular fracture; the granules vary from buff to a light brown with a tinge of Indian red. The rock has been bored by molluscs.

A sandstone cemented by crystalline calcite, dolomite, or in the alternative a very sandy crystalline limestone. The quartz grains well rounded with numerous, and some large, fluid inclusions. One grain which proves to be part of a quartz mosaic contains a fragment of rich brown mica. Yet another grain contains brown mica, and many have acicular microlites, possibly apatite. Considerably less numerous than the quartzes are felspar grains, both orthoclase and plagioclase. There are numerous fragments of a brown rock, apparently a palagonite, containing some crystals, including mica. The rhombs of dolomite are clearly marked out by concentric bands of dark brown inclusions, grains, and microlites, which tend to form radial bunches. In some cases the centre of a rhomb is completely darkened.

MARLS.

Under this heading are included hard marly limestones, those more exceptional forms from the Trias which are calculated to resist abrasion; with them is a smaller percentage of the true friable marl.

M. 34b. S. 28° W. Edd., 18·5 miles.

A dark red pebble, with smooth surface, much bored by molluscs. A cut surface shows very compact rock, the red colour of which is slightly mottled by a lighter shade. In the section this mottling is much more prominent. The rock is minutely granular, the mineral being probably a mixture of calcite and dolomite. There are also small angular fragments of quartz, and apparently some fibres of gypsum. Some of the borings have been infilled with secondary sandstone having calcareous cement. The stone is a very hard marl.

M. 9f. S. 31° W. Edd., 21·7 miles.

A fine-grained red marl.

Much very fine sand, with some larger quartz grains. The colour not uniformly distributed but mottled with grey. Many of the grains appear to be crystalline calcite or dolomite.

M. 31. S. 25° W. Edd., 15 miles.

Soft variegated marl, red and green.

M. 36. S. 37° W. Edd., 17·5 miles.

Hard chocolate-coloured marl.

M. 11. S. 26° W. Edd., 17·8 miles.
Hard chocolate-coloured marl.

M. 12. S. 26° W. Edd., 17·8 miles.
Hard chocolate-coloured marl.

M. 35. S. 32° W. Edd., 18 miles.
Hard chocolate-coloured marl.

M. 34. S. 28° W. Edd., 18·5 miles.
Hard chocolate-coloured marl.

M. 14. S. 24° W. Edd., 20 miles.
Hard chocolate-coloured marl.

M. 15. S. 27° W. Edd., 20·3 miles.
Pale red, rather soft marl.

M. 20. S. 25° W. Edd., 20·5 miles.
Hard chocolate-coloured marl.

M. 24. S. 24° W. Edd., 22·5 miles
Hard chocolate-coloured marl.

LIMESTONES.

The following dolomitic limestones would appear to belong to the New Red Sandstone formation.

M. 34d. S. 28° W. Edd., 18·5 miles.

A rather small brown-grey pebble, much bored by saxicava. Freshly broken surface is pale brown, and shows somewhat granular, very uniform, texture.

The section, examined by the unaided eye, suggests a slightly marked banded structure. The matrix of the rock is a fairly pure crypto-crystalline calcite and dolomite, and minute zoned rhomboids of the latter mineral occur sparsely. But it is so closely set with small sand grains that it might almost be described as a sandstone with calcareous cement. Most of these clear grains are probably quartz, but some show the repeated twinning of plagioclase felspar. A little brown mica is to be found, and rather numerous rich brown and black specks, which may be rutile. There are also many pale olive patches, distinctly larger than the other granular constituents, somewhat ill defined in outline and apparently calcareous. The calcareous ground-mass has here and there a yellowish-brown tint.

M. 35e. S. 32° W. Edd., 18 miles.

A very similar rock to the last described.

M. 21a. S. 25° W. Edd., 21·2 miles.

A compact horny-textured rock distinctly hard, but bored by

molluscs, etc. Colour of broken surface brown with a shade of purple, and buff. Weathered surface an uniform light brown.

A granular crystalline limestone, stained by iron in patches and lines. Apparently it has always contained some free spaces which are lined with larger crystal grains. Occasional almost complete rhombs of dolomite of small size occur. There are slight streams of a pale brown mineral of low double refraction; and scoriaceous looking inclusions of rich brown rock, containing small quartzes; these are the more aluminous parts of the rock.

PASSAGE BEDS—TRIAS TO RHAETIC.

M. 29a. S. 14° W. Edd., 19·8 miles.

A coarse, open-textured marl or marly limestone, drab coloured. The section shows widely varying colour and texture, giving at first sight the effect of a detrital rock with many derived fragments. That there are fragments of other marly limestones does indeed appear to be the fact; certain textures associated with definite colours, and with mineral forms not found generally distributed throughout the slide, are located in areas with well or less clearly defined boundaries. On the other hand, the same yellow iron stain which marks some of these areas runs irregularly across the section in a contorted and divided stream and is always associated with a finer ground-mass than the average.

In the general body of the rock, besides much granular crystalline calcite, occur small spheroids of a clear mineral, which consist of fibres radially arranged, and are also marked by a slight concentric zoning. One long vein shows the same structure, and its outline is botroidal. This mineral is soluble in HCl. There is a fair amount of dark material, which may be carbonaceous. Not infrequent quartz grains. And in the rather ill-defined orange-brown inclusions (if inclusions they are) a fibrous mineral in single blades showing a double refraction considerably less than that of mica; none of this is to be found in the residue after solution in acid, and it may be gypsum. One piece of certain mica is visible, with pleochroism from colourless to cinnamon-brown. The residue after solution in acid consists chiefly of a rich olive-brown isotropic matter in flocculent form.

M. 29b.

Compact, smooth, and fine-textured marl in thin slabs, can be marked by thumb-nail, drab coloured. The section shows very minute grains of calcite, and some brown fragments which may once have been mica.

M. 29c.

Angular fragment of stone-coloured marl, rather coarser than last, but still fine-grained and compact, just harder than the thumb-nail.

M. 29d.

Much like last, but has a greenish tinge.

M. 29e.

Like last, but harder and greener.

M. 29f.

Like last, but considerably softer, and greener still with patches of bright decided colour. Micaceous.

M. 29g.

Green marl and drab-brown marl as above in narrow alternate bands.

M. 29h.

A layer of coarse grey marl and one of fine-grained drab-brown marl.

The series **M. 29a.** to **M. 29h.** inclusive indicates a locality occupied by soft marls of varying texture and colour, associated in one and the same formation in layers of varying thickness, the alternations being frequent and repeated.

RHAETIC AND LIAS.

LIMESTONE AND SHALE.

Most of these limestones contain argillaceous matter; some, however, appear to resemble the White Lias; in the absence of field work it is not well to attempt to do other than group Rhaetic and Liassic together.

OFF LYME REGIS—*in situ.*

This type rock is frequently dredged off Lyme Regis.[24] The specimen shows coral fragments, including *Gonioseris*. For the rest it is a rough, somewhat sandy limestone, inclined toward a marl. A great deal of brown and black matter occurs in granular form. Obviously a Lias Limestone.

M. 12a. S. 26° W. Edd., 17·8 miles.

Drab-coloured stone, fine in grain. The section shows crystalline granular structure with no visible organisms.

M. 30a. S. 21° W. Edd., 21·5 miles.

Darkish limestone, rather brown than buff. Minutely crystalline granular. Traces of organisms; grains and slight micro-dendritic growths of iron oxide.

M. 53a. S. 22° W. Edd., 32·2 miles.

A light brown slabby rock, bored by molluscs. A closely-cleaved, highly-calcareous shale. Corresponds to the "paper shales." Distinctly marly. The section shows occasional aggregates of crystalline calcite. The chief part of the rock is a minutely granular pale brown

mixture, with mottling of rich orange-brown, less granular, substance, and grains and short irregular lines of an almost opaque dark brown. No undoubted organic remains.

M. 53b.

A light brown rock, a harder variety of the preceding, contains calcite veins, and one joint-face shows well-developed crystals. The laminæ of this rock are alternately of closer and of more open texture.

The section is made in one of the harder layers and corresponds with **53a**, except that it is lighter in general shade and the orange-brown portions are much less in proportion to the whole.

M. 53c.

Drab-coloured compact rock in slabs, one face of which is usually obviously a joint surface recently broken, and one face much bored, probably by annelids. The section shows a pale brown rock wholly but minutely granular, almost entirely calcite, with an occasional narrow vein of clear calcite, and small scattered brown and black granules. No trace of organisms. This forms the last of a series of which **53a** and **53b** are the first members.

M. 56a. S. 25° W. Edd., 34·3 miles.

A dull brown limestone of light shade.

Contains numerous fragments of shells and rather frequent echinoderm spines, but no foraminifera.

M. 44. S. 17° W. Edd., 29·8 miles.

Buff limestone, apparently liassic.

CRETACEOUS.

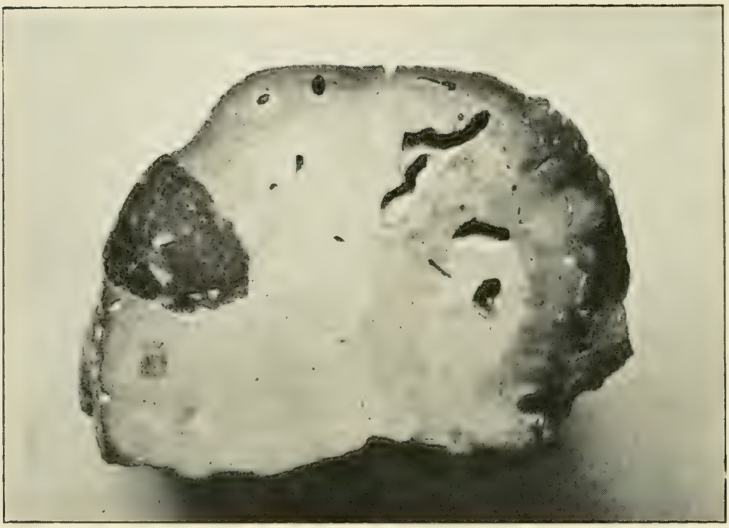
CHALK.

A very hard, yellow, or cream-coloured, chalk is of frequent occurrence; generally the exterior of the pebble is brown, and this colour extends some slight depth into the stone, getting less in intensity until it fades into the yellow or cream-colour. Unless the stone happens to be much bored it usually requires a considerable blow to break it.

M. 26a. S. 20° W. Edd., 18·4 miles.

Hard, cream-coloured chalk. Minutely granular texture. Crowded with small organisms. Many good sections of small foraminifera. Fragments of larger shells frequent. Some of the foraminifera infilled with a yellow-orange substance. Several textularia. Fragments of nodosaria, and some rotaline forms and globigerina.

Fig. 1.



M. 14a. S. 24° W. Edd., 20 miles.
Hard yellow chalk, surface finely ground but not polished.
Derived inclusion on left.
$\times 1\frac{1}{2}$.

Fig. 2.

M. 14a. S. 24° W. Edd., 20 miles.
Hard yellow chalk.
Ordinary light. $\times 97\frac{1}{2}$.

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M. 72a. S. 23° W. Edd., 19 miles.

Hard, cream-coloured chalk.

Texture minutely granular. Crowded with the remains of small organisms, and with shell fragments, etc.

M. 72b.

Hard yellow chalk. Shell fragments, small foraminifera, etc.

M. 21c. S. 25° W. Edd., 21·2 miles.

Hard yellow chalk. Crowded with foraminifera. There is a comparatively large circle of calcite ($\frac{1}{2}$ mm.) having radial structure, apparently the cross section of a cylinder, also shell fragments.

M. 14a. S. 24° W. Edd., 20 miles.

Should have preceded **M. 21c**, but placed last, because in some ways typical of the whole series.

A fair-sized pebble, some three inches in length, orange-brown on the outside, within distinctly yellow for an average depth of about 7 mm., then cream-coloured with small lighter patches. A somewhat irregularly bounded area on the surface is a darker brown and more compact than the rest, it is harder and stands slightly above the general level. Before the pebble was broken this measured over 30 mm. by 13 mm. On breaking the stone it was seen to be an inclusion extending 14 mm. inwards. This inclusion, viewed in cross-section, is green around the margin where it is in contact with the cream-coloured rock, and red in the interior and on its outside face. It has small curved cream-coloured markings, the largest 4 mm. by 1 mm., and in grinding down a section these markings were seen to all communicate with the original outer face of the inclusion; they are obviously borings made by some animal and have been infilled with chalk of the same character as the body of the pebble. This is the only specimen in which such a fragment has been observed, but perhaps closer inspection would discover more among the samples.

The section was cut through inclusion and general mass alike; it bears out in all respects the above description. There is a considerable similarity between the chalks forming the included fragment and the body of the pebble, but in the latter there are possibly more shell fragments; foraminifera are exceedingly numerous in both, and grains of glauconite are present in both. The cream-coloured rock has some considerable areas of calcite in interlocked crystalline grains; these are, however, infrequent. The whiter patches in the cream-coloured rock appear to be denser, to have fewer, although still very many, foraminifera, and smaller shell fragments, but there is no divisional line between the two. The foraminifera include Globigerina, Textularia,

Bolivina, Cristellaria, and Lagena. There are occasional black and dark brown specks. In all except its hardness the rock is distinctly a chalk. (Plate IX, figs. 1 and 2.)

Mr. D. J. Matthews has kindly made an analysis of a portion of the specimen above described, and returns:—

Silica (SiO_2) 0·70 *per cent.*
Calcium Carbonate ($CaCO_3$) 94·05 *per cent.*
Magnesium Carbonate ($MgCO_3$) 1·56 „
Phosphorous pentoxide (P_2O_5) 0·66 „
A little Iron and Aluminia.

Alkalies not tested for.

From the above it will be seen that the rock is both phosphatic and dolomitic.

Hard Yellow Chalk was also taken at the following stations, among others. The list is not quite complete:—

M. 31, M. 36, M. 33, M. 35, M. 15, M. 25, M. 17, M. 41, M. 58, and M. 67.

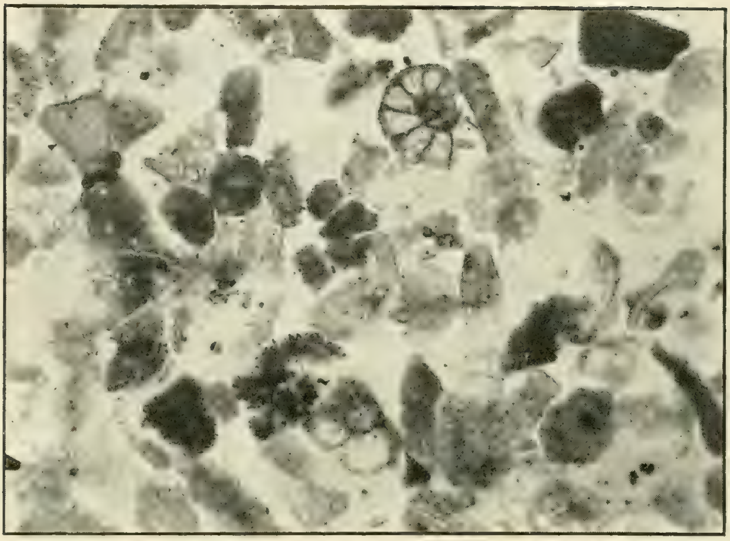
FLINT.

Flint is quite the commonest rock if the whole area covered by the dredgings is considered. It would be difficult to assert positively that it is anywhere entirely absent from the stony grounds. **A. 90**, about four miles toward Plymouth from the Eddystone, is all Devonian, but this was on a sandy ground.

Many of the flints are very unlike, in external appearance, any usually seen on land.[1] The unaltered mineral is very frequently black, but occurs only in the heart of the pebbles. A solvent action, not necessarily entirely marine, has removed a portion of the silica for some depth from the surface of the stone, and has left a white coherent gritty substance, which is sometimes soft enough to mark on a blackboard, sometimes quite hard. The progress of this alteration can frequently be traced in the section of a broken stone. Pebbles of some inches in thickness are often so far affected that a mere remnant, a patch of perhaps half an inch diameter, will be left in the centre to show what the former condition was. In some even of the large pebbles no unaltered flint remains. It seemed desirable to ascertain what proportion of the original mineral has been removed by this solution, and as an approximation the following method was adopted: **M. 15**. A piece of thoroughly altered flint, from a stone which showed some remnant of black flint

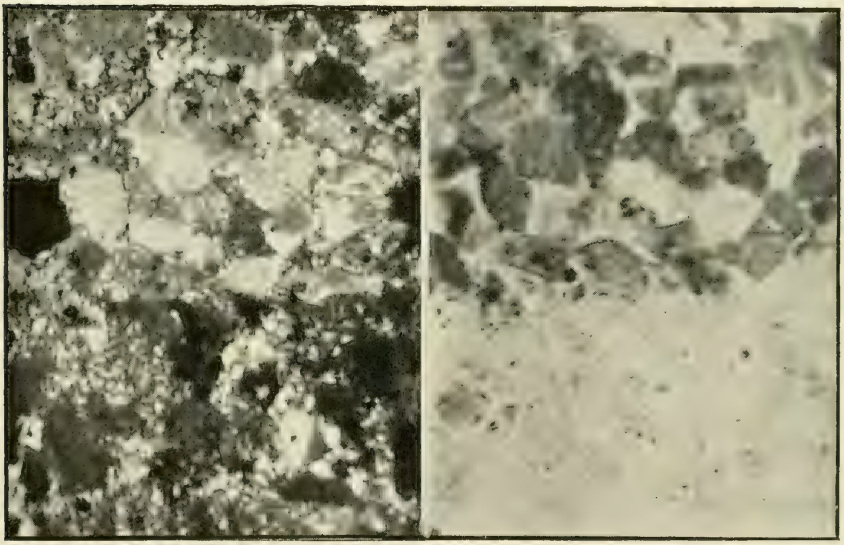
[1] Exceptionally, as, for instance, on Hardown Hill and Annis Knob, near Lyme Regis, chert and black Upper Chalk flint are found in much the condition here described, but the presence of carbonate of lime has not been reported, although probably existing much as in these specimens.

Fig. 1.



M. 62b. S. 25° W. Edd., 46·4 miles.
Decomposed black flint.
Ordinary light. × 97½.

Fig. 2.



M. 62b. S. 25° W. Edd., 46·4 miles.
Decomposed black flint, the lower half of plate represents portion of slide treated with acid.

Crossed nicols. × 97½.	*Ordinary light.* × 97½.
Shell fragments dissolved away from lower half.	Shell fragments dissolved away from lower half.

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at the centre, when dried weighed 51 grains; it was boiled in water for twenty minutes, allowed to remain in the same water until cold, when it was taken out, wiped, and found to weigh $62\frac{1}{2}$ grains. The specific gravity of the remaining mineral was ascertained to be about 2·56. If we assume that all the lost material was chalcedonic silica we have to multiply the weight of water absorbed, $11\frac{1}{2}$ grains, by the specific gravity of chalcedony, say, 2·3, in order to ascertain the loss of the original rock by solution; this gives us about $26\frac{1}{2}$ grains or somewhat over 33 % of the mass of the original flint. From the fact that the specific gravity of the residue is less than that of quartz, although some calcite also occurs in the rock, it may be assumed that not all the silica yet remaining is crystalline.

These porous altered flints effervesce, some more freely than others, on treatment with acid, but maintain their outward form. The same specimen on which the above determinations were made lost $3\frac{1}{2}$ grains in weight after prolonged stay in dilute acid. (This loss includes a very small amount of silica and the merest trace of iron.) It would thus appear that the unaltered rock had contained at least 4 % of soluble carbonate. In some instances this is certainly exceeded.

M. 62b. S. 25° W. Edd., 46·4 miles.

This specimen was selected for especial microscopic examination; it is a somewhat chert-like black flint, the outer portion altered as above described. The first section was made from the black part of the pebble, and shows the flint to be nothing more than a silicified chalk. Foraminifera and shell fragments, all still carbonate of lime, crowd the slide, and there are occasional quartz grains and some of glauconite. The matrix is partly crypto-crystalline, and so intimately is the crystalline mixed with the isotropic that practically all the silica ground-mass gives some reaction with polarised light. A second slide, cut from the decomposed part of the rock, shows a crypto-crystalline ground-mass of silica crowded with forms in calcite after organic matter. Foraminifera quite numerous, the chamber walls well defined, but the original structure mainly, if not entirely, replaced by granular calcite. An occasional fragment of some larger shell (molluscan) appears to have retained pretty well its original structure. Glauconite grains occur freely, and some of the foraminifera are infilled with this material.

Finally, to remove any possible ambiguity as to the presence of carbonate of lime, a third section was prepared, also from the decomposed portion. After this had been ground down to the requisite transparency one-half of it was varnished with Canada balsam, and the whole section dipped in dilute acid; a brisk but brief effervescence

followed. The slide now shows a clear-cut boundary; on the side which was varnished the foraminifera and shell fragments remain, on the other side they have vanished, leaving absolute vacancies. The crypto-crystalline silica is identical in character on either hand. The included quartz grains, which occupy the whole thickness of the slide, polarise in higher colours than the silica of the ground-mass, which is in too minute form to extend through the whole depth.

One interesting point is that the chalk thus converted into flint had not the same original structure as the yellow chalks described previously. (Plate X, figs. 1 and 2.)

The following further specimens were microscopically examined.

M. 15b. S. 27° W. Edd., 20·3 miles.

Decomposed flint. Lime not so common except in parts. There are instances of foraminiferal shell entirely replaced by silica. These are best seen by polarised light. In places the grain of the silica in the ground-mass becomes comparatively coarse.

M. 9h. S. 31° W. Edd., 21·7 miles.

Black cherty flint, with small light markings. The exterior reduced to a white loose-textured substance with minute brown spots. The varying resistance of the flint to decomposition is to be seen where the extreme outer surface has been chipped off, and small patches of almost unaltered rock are visible.

Shows the crypto-crystalline structure of the ground-mass very well. Much like other sections of the same material, except that the calcite fragments are larger, and there are iron-stained areas.

M. 18b. S. 29° W. Edd., 23·4 miles.

Decomposed flint. Hydrozoa and shell fragments, mainly in calcite, but some wholly replaced by silica of coarser texture than ground-mass. At one place slight dendritic growth of iron oxide.

Flint is present in greater or less quantity in every sample which yields pebbles or stones. Without actual count an approximate estimate of the proportion of flint to the whole sample has been made in most cases with the following results:—

A. 105. S.S.W. Bolt Head, 1 mile.
Flint in gravel 13 %.

A. 106. S. Bolt Head, 2 miles.
Flint in gravel 40 %.

M. 31. Flint two-thirds of whole.

M. 32. Thirty-seven pebbles, of which twenty are flint.

M. 36. Nine-tenths flint.

M. 10. Nine-tenths flint.

M. 33. Flint predominant.
M. 11. Nearly half flint.
M. 12. Three-quarters flint.
M. 13. About same as **M. 12**.
M. 35. Two-thirds flint.
M. 27. Much flint.
M. 26. Flint very plentiful.
M. 34. Over seven-eighths flint.
M. 72. Half flint.
M. 29. Some flints.
M. 14. Much flint.
M. 15. Three-quarters flint.
M. 20. Two-thirds flint.
M. 16. One-third flint.
M. 21. Half flint.
M. 30. Twenty pebbles, of which fourteen are flint.
M. 9. Nearly half flint.
M. 40. A little flint.
M. 22. Half flint.
M. 39. About half flint.
M. 24. About two-thirds flint.
M. 25. Almost entirely flint.
M. 17. Flint (no note of quantity).
M. 19. Very little flint.
M. 18. One-third flint.
M. 41. One-half large flints.
M. 43. Nine-tenths flint; one entirely altered, has been bored by molluscs.
M. 44. One-third flint.
M. 50. A little flint.
M. 53. One-third flint.
M. 56. One-third flint.
M. 77. Three-quarters flint, in large size, one about $6'' \times 6'' \times 4''$.
M. 58. Two-thirds flint, in large size, one about $10'' \times 6'' \times 4''$.
M. 67. Over nine-tenths flint, large and entirely unrolled, roughly cylindrical, with short branches, one 18 cm. × 13 cm. × 15 cm., one 21 cm. × 10 cm.
M. 62. One-half flint.
M. 79. Three stones, of which one is flint.
M. 80. A little flint.

EOCENE.

M. 77b. S. 11° W. Edd., 38·8 miles.

A rough-textured cream-coloured limestone, rather soft, and closely resembling the '*calcaire grossier*' of the Paris Basin.

Fine gravel or coarse sand is sparingly visible in the hand specimen. The microscope shows clear quartz grains, many of considerable size, and in the quartz fluid inclusions with bubbles. Fragments of

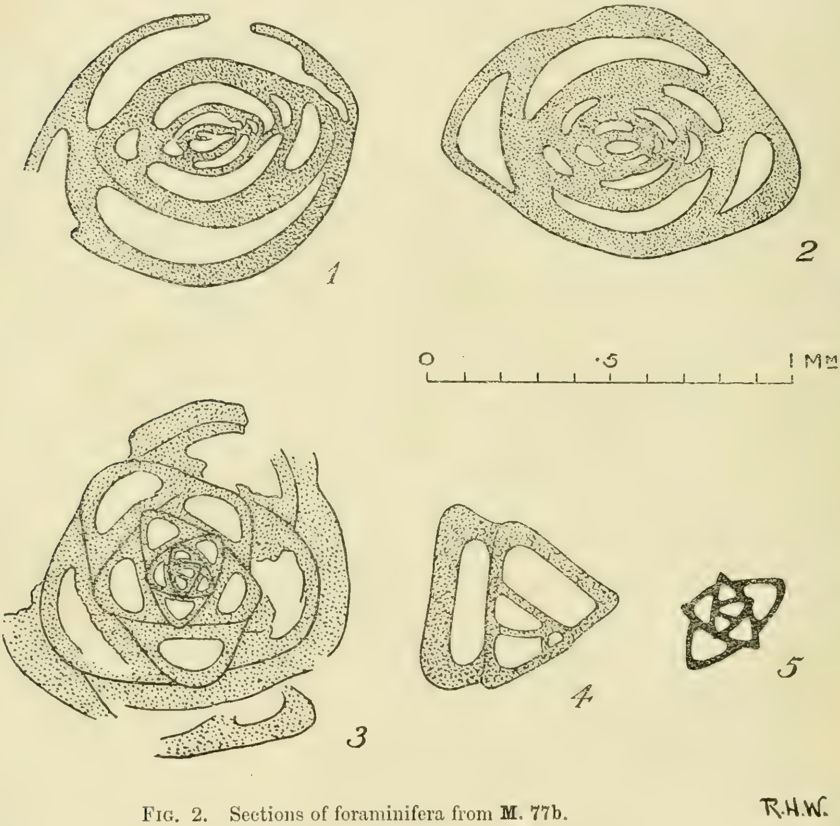
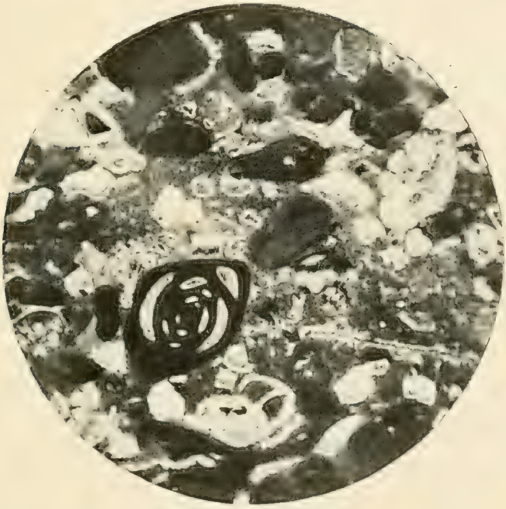


FIG. 2. Sections of foraminifera from **M. 77b.**
1.2.3.5. *Miliolina* (*Quinqueloculina*) *seminulum.*
4. *Miliolina* (*Triloculina*) *angularis.*

hydroids and of corals are clearly distinguishable. But the feature of the rock is its foraminiferal character. Various forms of *Miliolina* preponderate; these certainly include *Miliolina seminulum*, *Miliolina trigonula*, *Miliolina* (*Triloculina*) *angularis* (d'Orbigny), and possibly other varieties.

Of other foraminifera *Truncatulina refulgens* (Mont.) is identifiable, and there appear to be two species of *Discorbina;* one species of



M. 77b. S. 11° W. Edd., 38 miles.
Eocene limestone.
Ordinary light. × $33\frac{1}{2}$.

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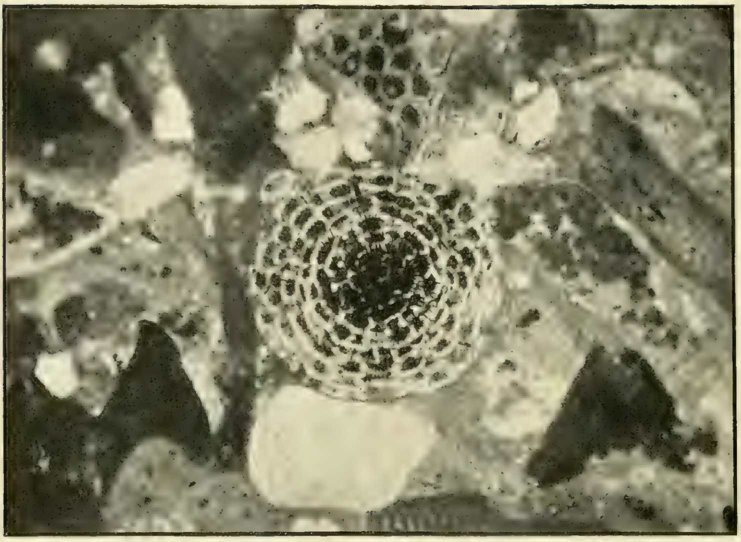
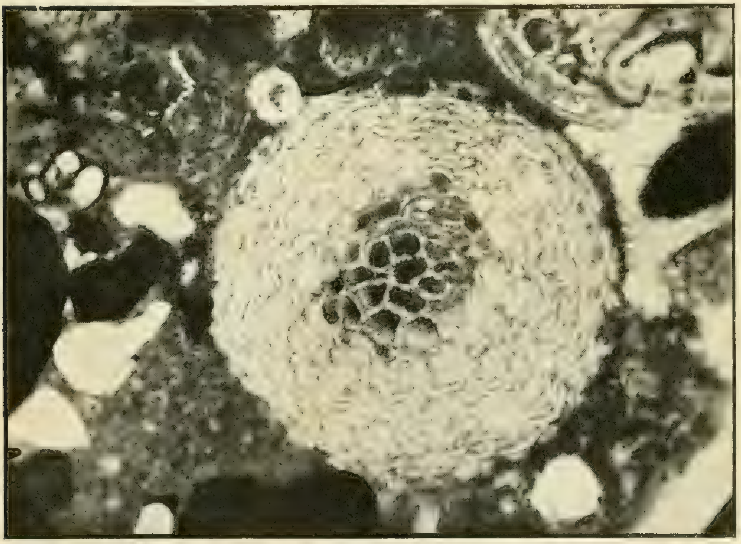
FIG. 1.



M. 77b. S. 11° W. Edd., 38·8 miles.
Section of *Planorbulina* (? *larvata*) in Eocene limestone.
Ordinary light. × 44.

FIG. 2.



M. 77b. S. 11° W. Edd., 38·8 miles.
Section of *Planorbulina* (? *larvata*) in Eocene limestone.
Ordinary light. × 44.

To face p. 157.

Verneuilina and one of *Textularia*, both the latter with arenaceous tests. *Biloculina ringens* is clearly present, and apparently a species of *Polymorphina* and one of *Spiroloculina*. There are several sections of a very beautiful foraminifera, all, however, in planes practically parallel to that of its spiral; still, cut at different parts of the thickness of the test, they give fairly clear information as to the form. It is certainly *Planorbulina*, and seems identical with *Planorbulina larvata*, Parker and Jones. This species is, however, only hitherto known as recent and of tropical habitat. The rock is too hard to admit the separation of the foraminifera as opaque objects, and sections must be relied upon wholly; so far three have been prepared, but many more will have to be cut before any certain identifications of the foraminifera can be made, except among the *Miliolinæ* and in a few chance instances where typical forms are fully displayed. Glauconite grains are common and of fair size, and the same mineral fills the chambers of many of the foraminifera. The foraminiferal shells have not been the subject of any mineral alteration. The groundmass of the rock has been a highly calcareous mud, with little aluminous matter. Comparatively shallow water conditions and a warm sea are indicated. (Plate XI and Plate XII, figs. 1 and 2.)

ROCKS OF UNDETERMINED AGE.

SANDSTONE.

M. 14d. S. 24° W. Edd., 20 miles.

A buff-coloured sandstone with calcite cement, appears rather open-textured on outer face of pebble, but is quite compact within.

By far the greater number of grains are quartz, but a few felspars show in the slide. There are also some shell fragments and other organic remains. Many quartz grains show acicular crystals of apatite, some few have zircon enclosures. Some are nearly free from fluid inclusions, but most show rather many, with bubbles in the majority of instances. Many of the grains are iron-stained yellow along cracks, obviously before inclusion in this rock.

This rock has all the appearance of a ragstone, and may very possibly belong to the *Neocomian* formation.

ARKOSE.

M. 62x. S. 42° W. Edd., 46·4 miles.

The fracture shows a pale pink rock; externally the worn surface looks rather like sandstone in which the cementing material is less hard than the sand grains, the fractured surface seems more like a granular felsite; felspar of a light flesh colour is clearly visible.

The section resembles a *breccia*, in which the individual grains are as well fitted to each other as the fragments in a tessellated pavement; thus there is a minimum of cementing matter. But, on the other hand, the normal constituents of granite, orthoclase, a little oligoclase, quartz, and some brown mica occur in much the proportions that would be found in a micro-granite, and very similarly distributed. Some of the felspar is micro-perthite. A great many felspars are cracked, some crushed, in each case the cementing material invades the crystal. Many of the quartz grains are similarly cracked, and the mica has been forced into curved forms to fit the surrounding grains, and in some cases has been structurally destroyed. The great majority of the grains of felspar and quartz show strain shadows in polarised light. The cementing material consists very largely of zoisite, with which is possibly a little felsitic matter. Small well-formed crystals of apatite and fluid inclusions with bubbles occur in the quartz. The felspar is fairly fresh and very little decomposed.

The rock has every appearance of a fine-grained granite, crushed, and then re-cemented by secondary minerals.

But for the appearance of the worn surface this would probably have passed in the hand specimen as a porphyritic felsite of the granitic class; it appears to agree precisely with the *Mimophyre quartzeux* of Brongniart, and the *Granite recomposé* of French petrographers.

A precisely similar rock is found at—

M. 13a. S. 26° W. Edd., 17·8 miles.

M. 30c. S. 21° W. Edd., 21·5 miles.

M. 44a. S. 17° W. Edd., 29·8 miles. Distinctly angular block.

Its range is, therefore, about 29 miles at least.

LIMESTONE.

M. 80e. S. 16½° W. Edd., 48·9 miles.

A large sub-angular stone, the surface distinctly polished. Very compact and hard. Brown with a vein of lighter buff or drab, dendritic markings on the lighter portion.

The section passes through both the mass of the specimen and a portion of the vein. Both consist of minutely granular crystalline material, largely calcite, but apparently dolomitic. The darker part gives indistinct evidence of organic remains, and shows clear rounded sand grains.

The rock is certainly puzzling, it may (doubtfully) have some affinity to the Cotham marble, but it would be a bold guess indeed to so identify it.

M. 51a. S. 15° W. Edd., 30·8 miles.

While this paper is in the press the writer has examined a rock from **M. 51**, which he had previously overlooked. This is a compact, dark brown limestone, with large shell fragments, now in calcite. The stone is angular. It is but little softer than **M. 80e**, and when sectioned shows dendritic markings similar to those in the lighter portion of that specimen. Undoubtedly liassic in type it in some sort forms a stepping stone from the more frequent forms to **M. 80e**, and the latter may now with fair certainty be identified as liassic. In mapping purposes this has been assumed.

GEOLOGY.

In the preceding section the various rocks have been assigned to their respective formations and their peculiarities noted. In Mr. Crawshay's paper their mode of occurrence, independently of their lithology, has been fully described. It remains to construct from the evidence thus called some coherent scheme of geology for this portion of the Channel.

With this end in view it is especially necessary to consider the probable date of these stony accumulations as such, and to find some reasonable explanation of their presence. Following which we must be assured that to some considerable extent the deposits are of local origin before we can proceed to any mapping of the various formations under the waters of the English Channel.

The one outstanding feature, as Mr. Crawshay has pointed out, is the general increase in average weight and size of the stones due south (magnetic), i.e. straight outwards into the Channel from the Eddystone. But although, as regards the dredged material, this fact is clear and important, against it or with it must be set the occurrence of large boulders on the Salcombe and Eddystone fishing grounds.

That the grade of the bottom deposit should grow coarser as the distance from land increases is against all probability and all experience, if the deposit is of recent formation under existing conditions. It should be expected that the detritus which enters the sea by the mouths of the rivers, derived from the denudation of the land, would so sort itself that the heavier and coarser particles deposit in the nearer and shallower waters, the lighter and finer particles coming to rest in the deeps; and, added to the river-borne detritus, the products of coast erosion and broken shells from the littoral zone should similarly distribute over the sea-bed with reference to the weight and size of their grains. No matter how small the rivers, how slight their supply of sands and clays, and without reference either to the rate of erosion and supply from the sea-cliffs, in time and in the absence of strong localised

currents the bed of any sea will become covered with deposits, the average grade of which at any place will bear a relation to the depth and the distance from land. And the strength of the sea currents will in most instances accentuate this differentiation, being greatest in shallower water.

If, then, a contrary condition is found to exist, and the sands are replaced, even in parts, in the deeper water by coarse beds and blocks of stone, it becomes apparent that these latter belong in their origin to other conditions than those now prevalent. The present rivers, the cliffs which we see to-day have not supplied their material. Further, we may surmise that a sea which exhibits this anomalous feature, that the materials of its bed grow larger in individual constituent parts with distance from shore, cannot be, in its present form and depth, of very ancient origin. The time available has not sufficed to enable the shore-derived material to spread over the whole area.

Austen has discussed these points very fully and with great clearness; in fairness to his work and in recognition of his precedence the matter may be stated in his own words[1]:—

"The law of progressive change in the character of the sea-bed requires that the most remote deposits of the Channel should be the finest, and that no coarse materials should occur at any considerable distance from the coast; this law holds good for a given extent round all the shores of the Channel, but beyond the area of mud and ooze, fine and coarse sands, shingle and bare rock are again met with. . . ." And referring to the coarse deposits on the Sole Banks and Jones Bank, "the whole of these groups [of coarse material] are separated from the zones of coarse materials depending on the coast-line by a broad intervening area of the finest quality of sea-bed. We are precluded from supposing that the lines of coarse materials can have travelled over the mud zones, as their upper surface is soft and incoherent, into which the sounding-lead sinks some distance before the mass is tenacious enough to stop it, and in which the dredge buries; if therefore marginal or sub-marginal zone materials are found in places beyond well-defined areas of the low moving power of water, they become a clear indication that since their accumulation a great change in the position of such place, as to depth of water and distance from coast-line, has taken place." . . . "It may be objected to this, that these distant sand, gravel, and shingle beds may belong to any age, and not in any way be connected with the present seas. In tracing the remains of marine animals seawards, we may observe a like gradual comminution with that noticed with respect to mineral

[1] "Valley of the English Channel," *Q.J.G.S.*, Vol. VI, 1850, p. 83 *et seq.*

materials, long after the forms of the shells have ceased to be recognisable. The sea-bed, particularly on the French side of the Channel, is mainly composed of shell sand, or sand in which few particles of anything but such as show shell-structure occur. Areas of this character are laid down by the French surveyors, and occur in the interval between the Land's End of France, or Ushant, and the Little Sole Bank; yet on the sides of this bank, and more particularly on its western slopes, large, perfect, though decayed, shells again occur, and what is more remarkable, *Patella vulgata*, *Turbo littoreus*, etc. Taking the two phœnomena together, the occurrence of littoral shells and of marginal shingle, we may safely infer that we have at this place the indication of a coast-line of no very distant geological period, buried under a great depth of water, and removed to a great distance from the nearest present coast-line."

". . . In the very coarse beds which form the floor or lowest levels of the deeps in the upper part of the Channel, from the meridian of Cape la Hague eastward, and which have a depth of forty and fifty fathoms, we also seem to have the highest marginal zone of some former period, over which the drifting beds of the actual period are spreading; and, on the other hand, such masses as Jones Bank are to be considered as protruding portions of an older sea-bed isolated amidst the ooze deposits of the present sea."

"... The character of the greater part of the Channel area, if laid bare, would be that of extensive plains of sand, surrounded by great zones of gravel and shingle . . .; whilst along the opening of the Channel there is an obvious configuration of hill and valley, and an amount of inequality equal to that of the most mountainous part of Wales."

Delesse attributes more to the action of currents in the deeper parts of the Channel than apparently would Austen, but agrees that the coarser deposits are not of the present epoch, and argues that the settlement of the sands and silts of to-day has been prevented in certain areas by the strength of the currents, and hence these earlier deposits have been preserved from being covered. He writes [1] :—

"La Manche étant balayée par des courants énergiques, on doit s'attendre à ce que son fond ne reçoive pas partout des dépôts, mais soit au contraire formé très souvent par des roches pierreuses antérieures à l'époque actuelle; c'est, en effet, ce qu'apprennent les sondages, et proportionnellement ces dernières roches y occupent même une étendue beaucoup plus grande que dans les autres mers. D'abord, elles présentent des surfaces très vastes dans tout l'Ouest de la Manche; elles bordent la Bretagne et la Cotentin auquel elles

[1] *Lithologie des Mers de France*, p. 308 *et seq.*

réunissent Jersey ainsi que les autres îles anglo-normandes; de plus elles réunissent la Bretagne au Cornouailles et le Cotentin au Sud de l'Angleterre. Elles sont découpées suivant des écharpes très irregulières; non-seulement elle longent les côtes, mais elles traversent complétement la Manche, se poursuivant jusque dans les parties les plus basses de son bassin et même jusque dans son thalweg."

"Ces roches sont assurément très variées; cependant entre la Bretagne, le Cotentin, le Cornouailles, et le Devonshire, elles appartiennent au granite et au terrain de transition. Les sondages font connaitre qu'elles sont en partie formées de pierres désagrégées; qu'en outre les roches pourries sont fréquentes autour de 49° 5′ latitude et de 7° 10′ longitude, dans le thalweg de la Manche."

Finally, when we deal with the boulders from the Salcombe-Eddystone grounds we have MR. HUNT'S opinion.[1]

"My own contention being that they [the boulders] are to all intents and purposes *in situ.*

"The problem of origin is certainly a perplexing one. Those who maintain a distant derivation have to show where the blocks came from, and how they came.

"Those who contend for a local submarine origin have to explain how such solid blocks could have become detached from the parent beds.

"That trawls could detach the blocks from their beds is as possible as that 'Old Noll' fired them at the seagulls; but that trawlers could have dragged them about all over the Salcombe fishing grounds when detached is practically certain. Thus none of the detached blocks have any claim whatever to be considered *in situ* when caught, though they may fairly claim, I think, to represent rocks forming the bed of the Channel not far distant.

"However, it is clearly impossible to prove that some of them may not have been ice-borne. Let those who maintain that theory show cause for their belief."

We are somewhat more favourably situate now than when either of the above extracts left the hands of their authors. As regarding a definite line, from Plymouth Sound, past the Eddystone to a distance of nearly fifty miles from the latter, we have absolutely located and perfectly representative samples of the bottom deposit. From the 25-fathom line to the 35-fathom line these have been worked out in detail. Broadly speaking, the results are that we now know the Eddystone and, in part, the Hand Deeps to stand above the general

[1] "The Submarine Geology of the English Channel off the South Coast of Devon," *Trans. Dev. Assoc.*, 1889, p. 484 *et seq.*

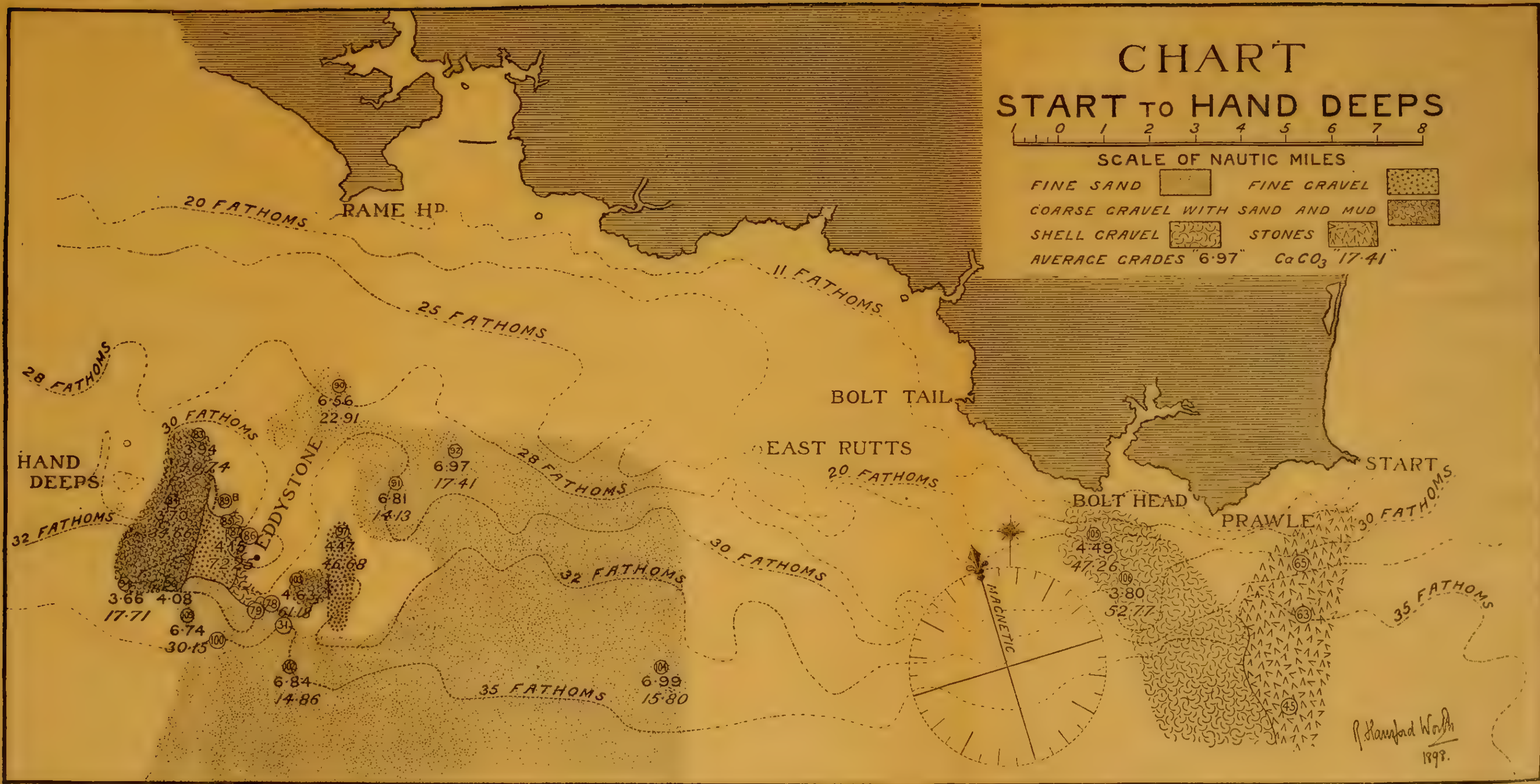


CHART
START TO HAND DEEPS
SCALE OF NAUTIC MILES
FINE SAND
FINE GRAVEL
COARSE GRAVEL WITH SAND AND MUD
SHELL GRAVEL
STONES
AVERAGE GRADES "6·97" CaCO3 "17·41"
RAME HD.
20 FATHOMS
25 FATHOMS
11 FATHOMS
28 FATHOMS
30 FATHOMS
32 FATHOMS
35 FATHOMS
HAND DEEPS
EDDYSTONE
BOLT TAIL
EAST RUTTS
BOLT HEAD
PRAWLE
START
MAGNETIC
6·56
22·91
6·97
17·41
6·81
14·13
3·94
20·74
4·47
46·68
6·99
15·80
6·84
14·86
3·66
17·71
4·08
6·74
30·15
4·49
47·26
3·80
52·77
R. Hansford Worth
1898.

To face p. 103.

level of a sea-bed which consists of fine gravel and fine shelly gravel in patches; while south and east for some distance from the Eddystone are fine sands. South of the Prawle promontory, off the coast-line from Bolt Head to Prawle, is shell gravel, from Prawle to Start, stony ground.

The fine sands are quite unlike the silty sand of Plymouth Sound, are coarser as a whole and cleaner. A chart which the writer prepared in 1898, from Dr. Allen's details, is here reproduced; the undetermined areas have not yet been fully worked, and perhaps are better left blank until full information is available. There is a little stony ground at East Rutts, a stony patch off Stoke Point, and stones have been dredged north of the Eddystone, and on the margin of the Hand Deeps. (Plate XIII.)

All the stations on this chart are those to which I have elsewhere prefixed the letter A.

Station **A. 100**, south of the Eddystone, gave large stones as well as sand. Stations **A. 78** and **A. 31**, although near to and surrounded in part by sand, were actually on rock, and **A. 79** yielded Triassic sandstone. These three points are southward from the Eddystone, on the margin of the fine-sand area.

The first matter, the probable date of the stony deposits and their origin, may now be left for a time, to be resumed when the general geological mapping of the area has been attempted.

As to the second matter, the extent to which we may rely on the comparatively local origin of the various stones and pebbles, this, too, may be left in part to a later portion of the paper, but enough should be written here to justify the attempted location of the various formations *in situ*.

When a rock is obviously torn from its parent mass, as instanced by its form and freshly-broken surfaces, and when it comes from known rocky, as opposed to stony, ground, the inference as to its *in situ* origin is almost irresistible.

This is a matter of rare occurrence. HUNT'S **H. 19** appears to have been a clear instance. The trawler *Pelican* got fast in what was supposed to be a wreck, and remained thus fast for some hours. When the trawl came away, a fragment of granite showing a clean fracture was found in it. This fragment, No. 19, differs from HUNT'S other specimens in that it evidently formed part of a thin slab of rock, and not of a massive block. The stone proved to be a granite of coarse grain, with white and black micas, and a little triclinic felspar in addition to the orthoclase. The locality 20 miles S.W. of Eddystone. From practically the same spot, **M. 15**, the recent dredgings

raised a fine-grained granite also with both brown and silvery mica.

There is evidence that the rock bottom at **A. 78**, **A. 79**, is Triassic. While the gneiss from **A. 86** (354/1), ½ mile N.W. of Eddystone, was a large angular slab, with one face of apparently clean fracture.

Thus on this class of evidence granite, gneiss, and trias have alike been found *in situ*.

Another feature that argues strongly for a rock being near its first home is the angular or sub-angular form occasionally presented; especially is this form of evidence of value when the stone is such as will readily suffer from transport.

A. 100 (354/2), 2 miles S.W. of Eddystone, gave large stones, a thin slab of variegated Triassic sandstone, a rather thin slab of buff Triassic sandstone, and a thin piece of red marl, all angular and practically unworn. Such rocks as these could not travel without great wear.

M. 19. S. 28° W. Edd., 23·3 miles, yielded large square blocks of Red Triassic Sandstone.

M. 14. S. 17° W. Edd., 29·8 miles, yielded thin sharp slabs of Liassic limestone.

There are other similar instances. Evidence of this type again demonstrates practically *in situ* exposures of Trias, and in this case of Lias as well.

A third clear indication of localisation is when the adjacent sea-bottom yields rocks of the same class and type as shore exposures. The sea-bed off the Bolt and around the Eddystone affords instances.

To some extent coupled with this is a fourth strong class of evidence —the restriction of the occurrence of a given type rock to areas with definite boundaries. Thus the Bolt and Prawle schists vary in type as we proceed southward along the sea-bed. The Eddystone and Hand-Deeps gneisses are restricted to the immediate neighbourhood of the reef; in **A. 102, S. Edd., 2½ miles**, the gravel contained no Eddystone reef material, although in **A. 87, N.W. by N. Edd., 1 mile,** 87 % of it is derived from the reef. It will presently be seen how, on a much larger scale, the New Red Sandstone series is definitely bounded. Thus at **M. 27, S. 19° W. Edd., 18·3 miles,** there is a representative series of Triassic rocks; at **M. 29, S. 14° W. Edd., 19·8 miles**, these are entirely replaced by the marls of the passage-beds to the Rhaetic. The distance is under two miles.

Another, the fifth, possible proof that a rock is near its point of origin applies in but a few cases. An example will best explain it. On all the preceding arguments we may decide that the gneiss of the Hand Deeps is practically *in situ*. **354/3b** is a red conglomerate of the

New Red series; it contains derived fragments of the Hand Deeps gneiss and schist; it is found side by side with them, and hence if they are *in situ* so, too, in all probability, is it.

The sixth line of argument for the demonstration of the local origin of the rocks and pebbles is as strong as any. There are some rocks so friable that they might not travel half a mile without being destroyed. Many of the marls of **M. 29** above referred to are of this class, the 'paper shale' of **M. 53a, S. 22° W. Edd., 32·2 miles,** is another rock which must be content to rest at home or be destroyed. From these which cannot be moved without destruction, through those which can only travel a little way without disintegration, on to others which may journey but must be considerably reduced in their progress and bear evidence of their wanderings, there is a complete succession. The extreme of the class may be taken to be flint, and if entirely unrolled flints are found, as at **M. 67, S. 19° W. Edd., 40·5 miles,** among other places, it may well be assumed that they are untravelled.

On some one or more of these six lines of argument every class of rock found in the dredgings may be shown to be practically *in situ* at one or more stations. Its associates are arguably almost equally near their points of origin, for it is impossible to attribute to any drift, arising from whatever cause, the selective and confounding ability to bring like to like, to transport from a distance and place among its kin any stone or stones. A little exchange of material between adjacent areas there must be, but we are not about to attempt any geological mapping within extreme narrow limits of error.

THE CRYSTALLINE ROCKS.

Granites, Diorites, Gneiss, Schist, etc.

Mr. A. R. Hunt quotes, in a paper above cited, a letter received by him from the late Mr. E. B. Tawney, as follows:—

"My views are rather Britannic; I look to Brittany for their origin [the origin of the Channel granites and gneisses, R.H.W.]. I consider Brittany reached to Plymouth Sound and then stopped short, but am inclined to give Start Point to it. If so, the granites are *not all* pre-Devonian, though pre-Carboniferous."

To much the same conclusion the writer has arrived, as at least a working hypothesis, with the correction that some at least of the Brittany granites are now commonly accepted as of Carboniferous age.

To one who has worked in a granite area such as Dartmoor there is nothing unexpected, nothing disappointing in finding, as in the present instance, such considerable variety among the plutonic rocks,

a variety that by no means in all cases involves difference of origin.

For the moment all granites and associated rocks which may have had a Dartmoor origin are excluded from consideration; these are extremely few in number. The first part of this paper must be left to speak as to the variety of the plutonic rocks met in these dredgings. But here such slight evidence of relative age as can be adduced may well be considered. Gneiss is known to occur at the Eddystone *in situ;* it occurs also at the Hand Deeps and the East Rutts, and notwithstanding the doubt thrown upon the fact, I am inclined to consider that the 'Shovel Reef specimen' was, indeed, obtained near Plymouth Breakwater. This has been rendered the more probable by discoveries made since the time when Mr. A. R. Hunt, on evidence that warranted him in all fairness, challenged the fact.

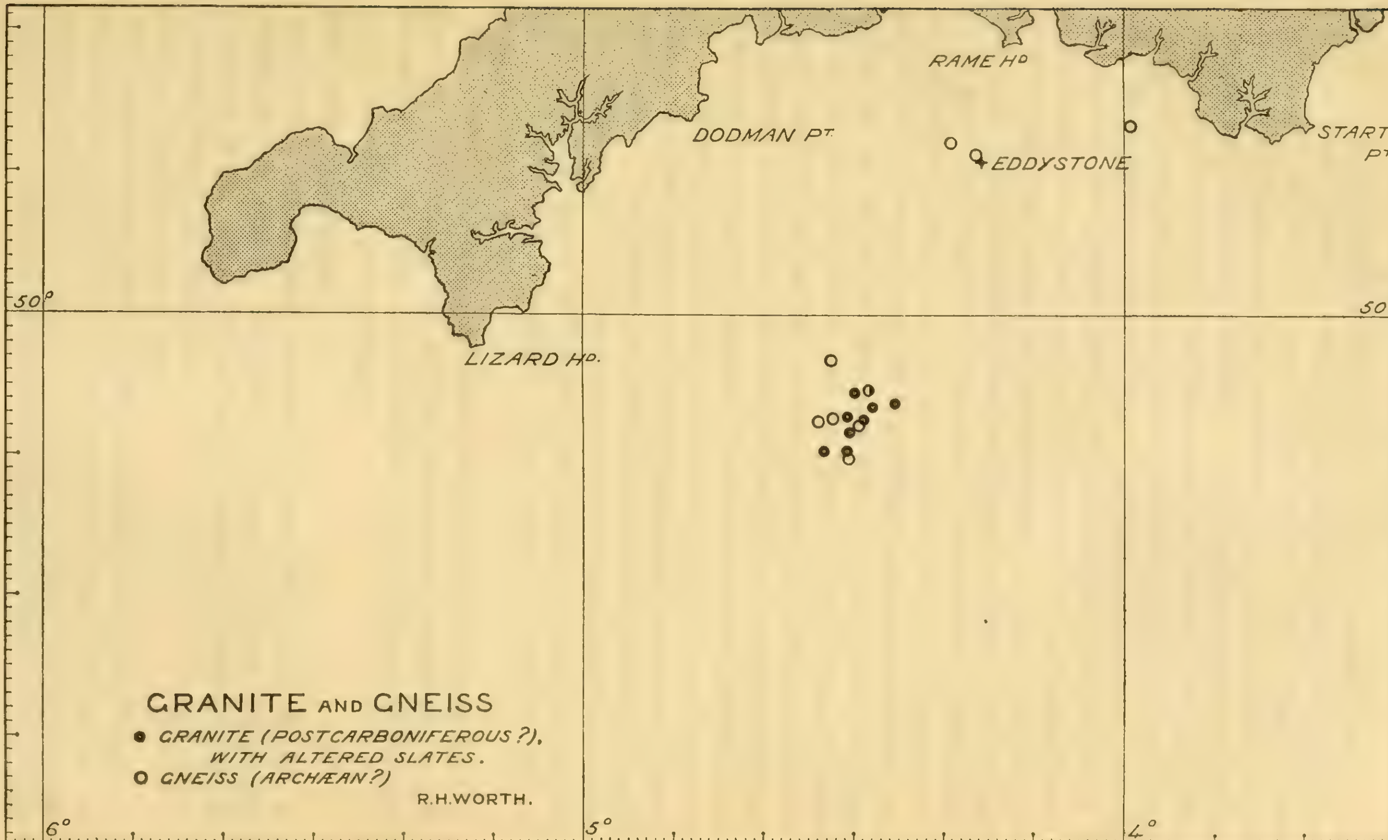
We now know, as we did not then, that gneiss occurs at the East Rutts, and chlorite schist off Stoke Point, in each case without any trace of their presence being visible on shore.

Gneiss also occurs at **M. 36, M. 9, M. 16,** and **M. 25** stations, which all lie in a narrow north and south strip, extending from 17·5 miles S. 37° W. from the Eddystone to 23 miles S. 24° W. from the Eddystone, a strip not quite three miles broad. **M. 11x** and **M. 20g** might also be classed as gneiss, and would somewhat broaden the patch referred to. In any event there is a certain localisation about these associated rocks. The writer has always hitherto leant to the hypothesis that the Eddystone gneiss was of Archæan age. From the features of similarity the gneiss from this area would presumedly be of the same formation. And there is an interesting piece of evidence which at least tends to indicate age. A number of grit stones have been dredged from various parts of the area examined (see p. 142). Among these is **M. 9d**, and that rock contains as derived fragments particles of just such gneisses as occur in the neighbourhood.

It is impossible to correctly date the grits, which may be either Carboniferous or earlier, perhaps more probably the latter.

Turning next to the schists. One of the most interesting finds was off Stoke Point, where chlorite schist is not uncommon (see p. 139). This brings the Bolt series many miles west. For the rest, the petrological notes give all the useful information.

As bearing on the age of some of the plutonic rocks we have to observe that there is an area over which slates are common which show evidence of contact metamorphism. The northernmost point of this area is **M. 11, S. 26° W. Edd., 17·8 miles,** the southernmost is **M. 24, S. 24° W. Edd., 22·5 miles,** about five miles long; the patch is from one to


RAME H^D
DODMAN P^T
EDDYSTONE
START P^T
50°
50°
LIZARD H^D.
GRANITE AND GNEISS
GRANITE (POSTCARBONIFEROUS ?), WITH ALTERED SLATES.
GNEISS (ARCHÆAN ?)
R.H.WORTH.
6°
5°
4°

To face p 166.

three miles in breadth (see p. 144); it is quite possible that similar rock in small quantity may occur outside this area and have been overlooked. **M. 14j** has been taken as the type. Possibly these slates are carboniferous; they more resemble the carboniferous series lithologically than the Devonian. It is to be noted that side by side with these slates occurs a red felsite, and red granites occur also. This distinctly looks like an area where the contact plane of the granite and the sedimentary rock is near to or reaches the surface. Felsites and red-coloured granites would be expected near the junction. If these slates are carboniferous, then the granite is post-carboniferous; if Devonian, the granite is post-Devonian, in any event not pre-Devonian. Some interesting features attend this area of altered rock. It is true that Hunt's **H. 19** granite *in situ* occurs 20 miles S.W. of Eddystone. Here, too, have been found the only specimens of schorlaceous granite or aplite **M. 11c, M. 27x**; hence come the other true aplites **M. 24g, M. 14e, M. 34e**; and hence we derive the micro-pegmatite, **M. 11a.**, all granitic, and not dioritic rocks. The only schorl rocks, except **M. 14f** and **M. 72**, come, however, from **M. 31** and **M. 36**, one to two miles north of this area, and possibly in the absence of **M. 11c.**, **M. 27x** would be regarded as strays. Such was the writer's first thought; but considering the nature of the adjacent rocks, he now inclines to believe that both schorl rock and schorlaceous granite truly belong to the area. The presence, in addition to the above-named, of diorite, quartz diorite, and some intermediate igneous rocks is not overlooked.

The areas of gneiss and altered slate lie side by side, but neither can claim exclusive occupation of its portion of the bed of the Channel. (Plate XIV.)

Since very little good can result, with the present materials, from any further attempt to deal with the plutonic and metamorphic rocks, we next turn to the New Red Sandstone, which overlaps and partially overlies the district just considered.

NEW RED SANDSTONE.

The westernmost shore exposures of New Red Sandstone are at Thurlestone in Bigbury Bay, and in Cawsand Bay on the Mount Edgcumbe shore. There is also on the beach at Drake's Island in Plymouth Sound an untravelled block of breccia of Triassic aspect, weighing about four or five tons.

The mica-andesite (felsite of the Geological Survey) at Withnoe in Whitsand Bay is an intrusive rock, evidently connected with the red trap in Cawsand Bay, and undoubtedly of New Red age. **354/4b** 6½ miles W. from Rame Head lies on another exposure of this same igneous series.

De la Beche, whose work stands as a model of careful discovery and accurate inference, with reference to the red trap of Cawsand writes: "Though unable to adduce direct proof, we are inclined to refer this porphyry, from its general character, to the date of the lower part of the red sandstone series, and to infer that it may be connected with a portion of that series beneath the sea in the direction of Bigbury Bay, on the coast of which, near Thurlestone, we find the patch above noticed."[1]

In 1867 Pengelly, and in 1886 Worth, supplied proof and confirmation as to the age of the 'porphyry.' And in 1898 the writer, as the result of Dr. Allen's dredgings, was able to assert that there was strong evidence that from the Hand Deeps to Bigbury Bay the New Red rocks were continuous. It may now be added that conglomerates dredged from off the *Mewstone Ledge* are distinctly of the New Red type. In the gravels and sands between the Eddystone and the Bolt New Red materials everywhere constitute a considerable percentage of the rock fragments.

In the vicinity of the Eddystone and the Hand Deeps New Red rocks are found *in situ* (wherever rock is exposed), through which protrude the reefs. The conglomerate at the Hand Deeps contains fragments of the local schists and gneisses.

The lithology of these rocks having been fully treated of in the first part of the paper, it is not proposed to make any repetition here, but pages 144 to 148 inclusive may be referred to. Although the variety of the rocks is considerable, all, or almost all, appear to be Triassic rather than Permian in character.

Only one of Hunt's specimens has any bearing on this formation, and that is **H. 10**, S. Edd., 20 miles—"Triassic Sandstone."

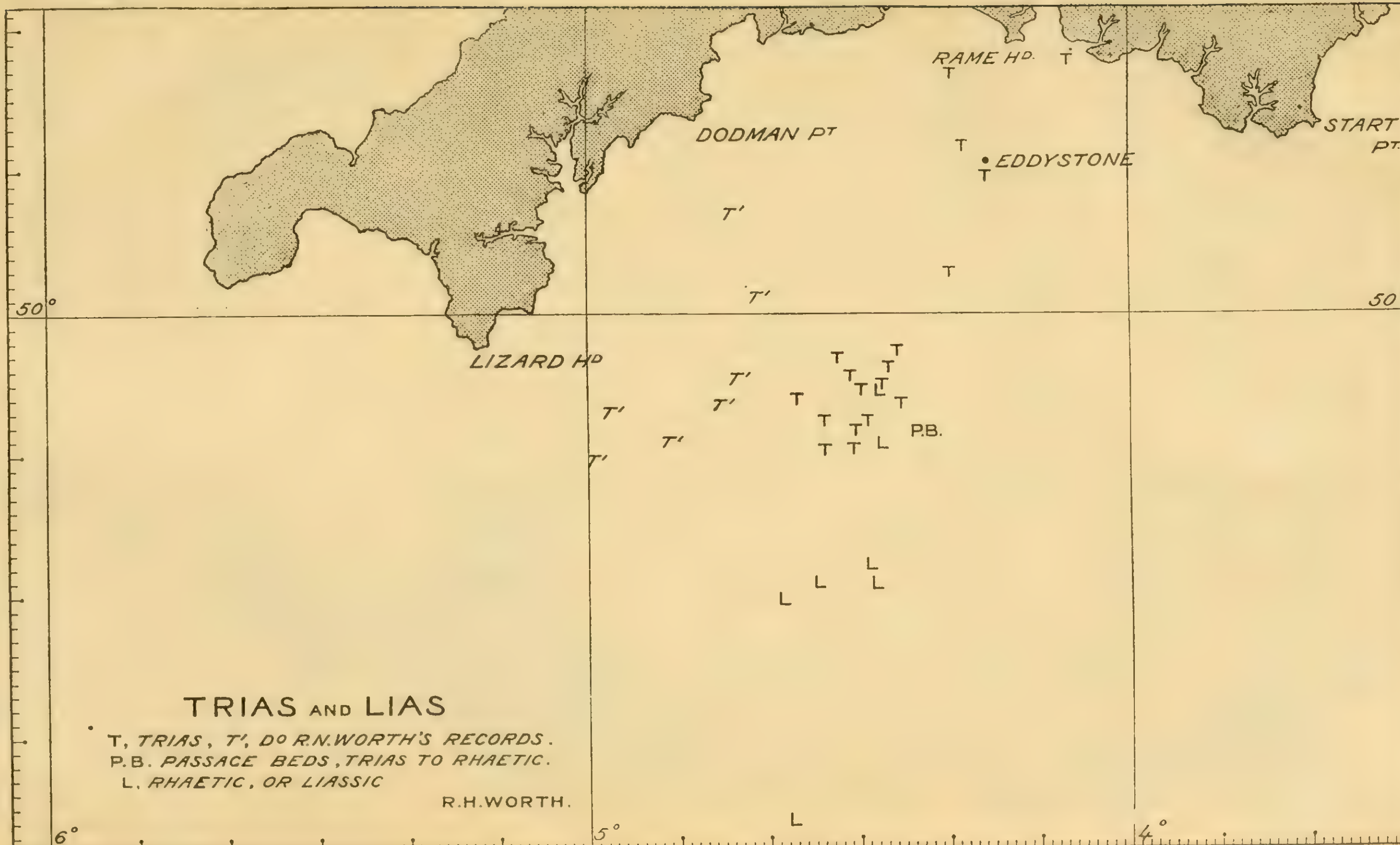
Worth's discoveries further westward, meeting and overlapping the Association's latest dredgings, are of especial importance; these carry the Trias to a point **W. 5**, S.W. by S. (mag.) Dodman, 25 miles, roughly 36 miles from the Eddystone.[2] He doubted the eastward extension of the outlier, on evidence which has interest as confirming the Association's results. In fact the Trias does so extend, but his two easternmost points lay one on either side of the broad belt which it forms. His **W. 12**, S. by E. Dodman, 27 miles, lies about 3 miles north-east from **M. 29**, and at the latter point we now know that the Trias has given place to higher strata. **W. 12** yielded no Triassic rocks.

His **W. 6**, S. by W. Dodman, 20 miles, in addition to a salmon-tinted

[1] *Report on the Geology of Cornwall, Devon, and West Somerset*, p. 212, 1839.

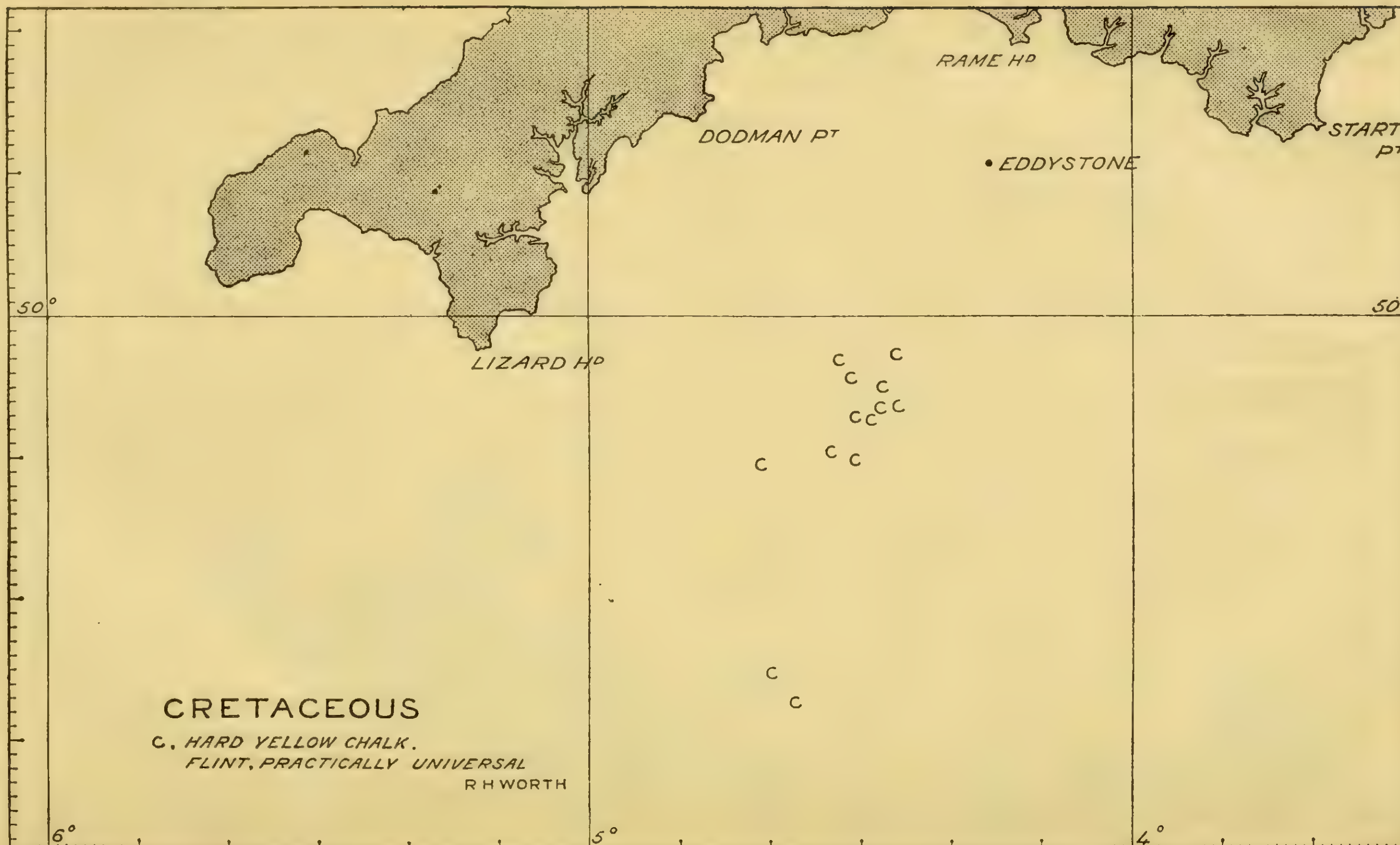
[2] "On a Submarine Triassic Outlier in the English Channel," *Q.J.G.S.*, Vol. XLII, 1886, p. 313–15.

Plate XV.



To face p. 168.

Plate XVI.



To face p. 169.

calcareous sandstone (Triassic), yielded pebbles of granitic, granitoid, and quartzite rocks, with flints, thus confirming **M. 40**, five miles westward.

On the chart here inserted the letter T indicates those dredgings made by the Association in which *New Red* rocks have been found; while WORTH'S records are marked T'. (Plate XV.)

The point at which the *passage-beds* above the Trias were found is marked P.B., and L indicates limestones and marls of *Liassic* type.

CRETACEOUS.

Inasmuch as flints are recorded from practically every dredging, it is useless to place the localities on a special chart.

A chart has, however, been prepared showing the distribution of the hard yellow chalk. The northernmost location would appear to be HUNT'S **H. 13, S.W. Edd., 15 miles**; his record of "a small piece of buff-coloured limestone, riddled through and through by molluscs and other marine borers," probably refers to a piece of this chalk. From this point to **M. 41**, a distance of, say, 11 miles, records are frequent in the Association's dredgings. There is then a gap for about 14 miles, and following this two localities occur, **M. 58** and **M. 67**. (Plate XVI.)

The affinities of this yellow chalk appear to be with the 'Melbourn Rock,' described by Mr. A. J. Jukes-Browne, and later by the same author in collaboration with Mr. W. Hill.[1]

Whether lithological similarity in this case implies identity of age may be doubtful. But the writer is indebted to Mr. Jukes-Browne for the loan of some slides from his collection, and finds much in common between these and his own slides prepared from the dredged material. Unfortunately the latter contains no recognisable remains of any zonal fossils. If of the same age as the Melbourn Rock, the specimens indicate a formation lying at the base of the Middle Chalk.

EOCENE.

The one block of Eocene limestone is of great interest; it is large, over one foot in length, flat-bedded, and angular. From its nature it cannot have travelled far and preserved its present form; indeed, it must practically have been taken *in situ*.

The possibility of Eocene strata occupying some part of the western bed of the English Channel had been recognised before this specimen was taken, and the grounds for that recognition have been so well summarised by Mr. Jukes-Browne, that no apology is needed for inserting here an extract from his work, *The Building of the British Isles* (1892):—

"From the superposition of marine limestones upon the lignitic

[1] "The Melbourn Rock, etc.," *Q.J.G.S.*, Vol. XLII, 1886, p. 216 *et seq.*

series of the Paris Basin, and the sudden appearance in them and in their English equivalents of tropical forms of mollusca, it was formerly supposed that a subsidence took place which submerged part of the intervening land and allowed the waters of the great Eocene Mediterranean to occupy a portion of the low-lying tract on the northern side of the barrier. But the discovery by M. Vasseur of deposits with fossils of the Calcaire Grossier age near the mouth of the Loire, and the identity of their fauna with that of similar deposits in the little basin of Carentan in Normandy, makes it much more probable that the

FIG. 3. The English Channel in the Middle Eocene Period. Land areas shaded. (After Jukes-Browne.)

incursion of warmer water came from the Atlantic. Professor Hébert remarks that the height of the ground between Carentan and Rennes makes it impossible to suppose that these two basins were directly united. Brittany must have formed a promontory between the inlet of the Loire and a channel which ran through what is now the opening of the English Channel. M. Dollfus is of the same opinion, and has recently proved by his researches along the south side of the Paris Basin that there was a continuous shore-line along that district throughout the whole of the Eocene period.

"It is fairly certain, therefore, that the opening was westward, and was nothing less than an incursion of the Atlantic into the North

European region. We may suppose that the Atlantic waves had long been thundering against the western land which united France to Ireland, and that at last only a narrow tract of rocky land between Cornwall and Brittany remained to separate the western ocean from the lowland of the Anglo-Parisian area. The final breaching of this was accomplished during the subsidence to which the Calcaire Grossier testifies; the waters of the Atlantic soon widened the straits, and established a sub-tropical fauna and flora on the southern shores of Britain."

Mr. Jukes-Browne gives a map showing the geography of the Anglo-Gallic area as so interpreted; this with some addition and curtailment is here reproduced (Text, fig. 3). The Eocene of Carentan has been marked 'C,' the similar strata near the mouth of the Loire have been marked 'L,' and the position of the dredging M. 77, from which came the Eocene limestone, is indicated by the letter 'E.' The confirmation afforded by this discovery to the views of French geologists, in a problem the key to which lies in their country, is a pleasant matter to record.

GENERAL CONCLUSIONS.

The affinities of the crystalline rocks in the area examined are strongly toward Brittany, and but slightly toward the mainland of Devon and Cornwall.

There is evidence, amounting at the least to a strong suspicion, that the granite which occurs at and around a point 20 miles south 26° west from the Eddystone is post-carboniferous; and this granite exhibits a tendency toward the Dartmoor type.

The Triassic outlier off the Lizard and Dodman discovered by the late R. N. Worth has proved to be connected eastward with an even larger area of New Red Sandstone rocks, which may very probably be continuous with the nearest shore exposures.

A clear indication of the eastern boundary of the Trias has been found at a point about 20 miles south 17° west of the Eddystone. There seems fair reason to suppose that the western boundary of the Jurassic formations may for a short distance approximate to a line drawn south-west from this point. It may, however, be noted that Lias limestone was found in a detrital deposit at Cattedown (Plymouth) by the late R. N. Worth.

The Cretaceous rocks dredged from the Channel are now for the first time recognised to include chalk as well as flint. There is some possibility that the rock found is from the base of the Middle Chalk.

Flints, in addition to occurring on modern beaches, are found also in the raised beaches of Devon and Cornwall; were very numerous,

associated with Dartmoor rocks, in the detrital deposits lying on the limestone at Cattedown, and examined by R. N. Worth; have been found by the writer, again associated with Dartmoor rocks, on the floor of clay-filled fissures in the Plymouth Limestone 20 feet below low water, and have been found by him on the rock beds of the Plymouth estuaries, buried beneath the silt.

As a result of the dredgings a considerable westerly extension of the boundary lines of the Trias, the Lias, and the Cretaceous must be made on our maps, beyond the present usually accepted speculative bounds. And the theory of an Eocene drift, sometimes put forward to account for the flints, must be abandoned.

It appears that from distant geologic time a depression has existed, having the same trend as the western part of the English Channel, and occupying a part at least of the same area. The New Red Sandstone first distinctly shows the previous existence of this depression. From Torbay to Plymouth the northern verge of the New Red deposits touches the present shore-line here and there; always the derived fragments in the conglomerates and sandstones are largely from local rocks. From Plymouth to nine miles south-east of the Lizard it runs parallel to the coast without absolutely touching it, and how far further west it extends we do not at present know. An arm of the great inland sea of this period, probably of its later or Triassic years, had its northern shore much where the waters of the Channel now meet the cliffs of Devon and Cornwall. How wide the Trias lake was along this western extension cannot at present be known; its deposits are lost under those of the succeeding Liassic sea, perhaps to reappear nearer France, perhaps not.

During the later Jurassic period this depression would appear to have slowly risen free from the waters, and in part, if not in whole, to have become a subaerial valley.

The Cretaceous era witnessed its entire submergence, although the highest points of Devon, where Dartmoor and Exmoor now stand, may have appeared as islands above the surrounding waters.

This submergence was gradual. A problematic coast-line of the time of the Lower Chalk has been laid down by Mr. Jukes-Browne.[1] By that author's consent the map accompanying his paper in the *Transactions of the Devonshire Association* is here reproduced (Text, fig. 4).

It may be that the westerly extension of the Cenomanian sea has not been sufficiently prolonged; be that as it may, the sea of the Upper Chalk sent an arm westward to the Lizard parallel or probably beyond.

[1] "Devonshire in the Time of the Lower Chalk," *Trans. Dev. Assoc.*, Vol. XXXV, 1903, p. 787 *et seq.*

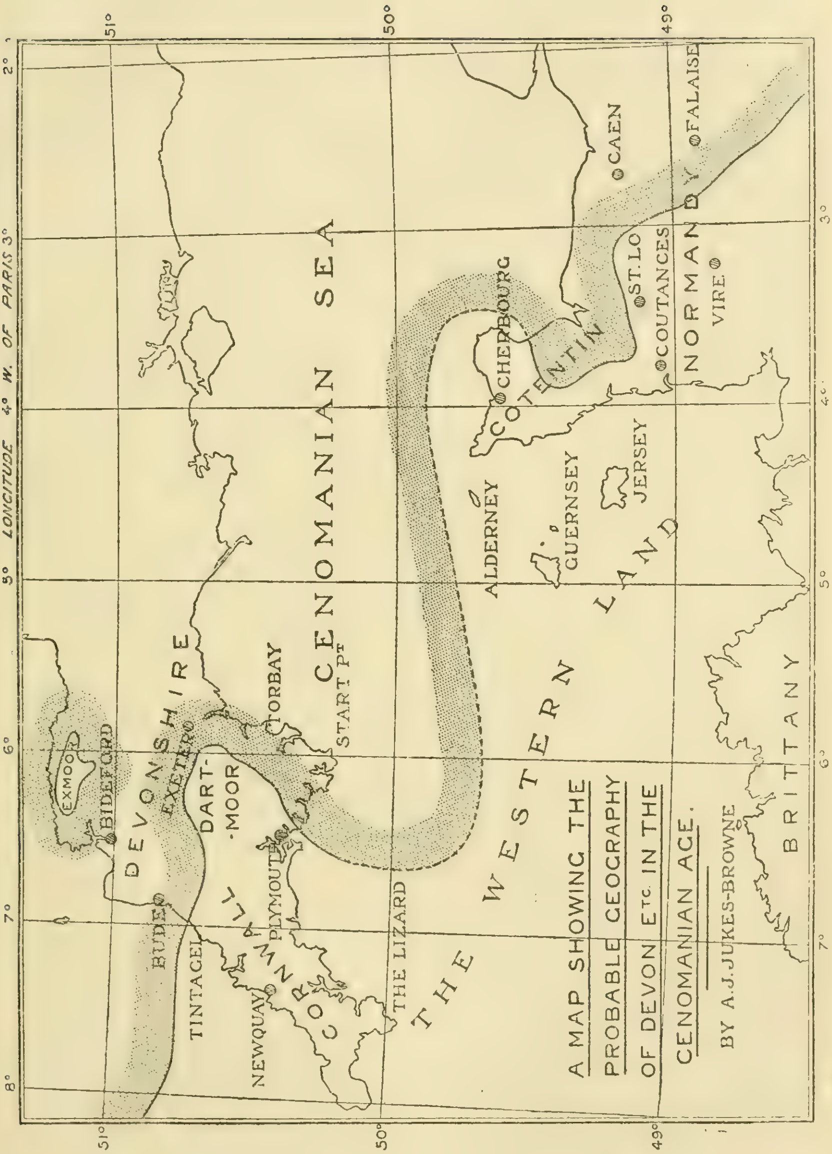


FIG. 4. Map showing the probable geography of Devon, etc., in the Cenomanian Age. (By Jukes-Browne.)

The next movement of the earth's surface involved an emergence of the land, and the depression which we are considering came into subaerial conditions once more; how far it had been filled in the meantime by chalk rocks and its features obliterated cannot be decided. We may imagine the denudation and solution of the chalk to have at once commenced, and for a period there existed over the site of the English Channel a valley draining eastward.

At this time a profound change in the geography of Northern Europe was imminent; the Western Land was slowly yielding place to the sea, and already Atlantis was almost lost in the ocean. A renewed subsidence brought the eastern sea in constant encroachment westward over the site of the Channel and helped bring the Atlantic eastward toward it. In the Middle Eocene period the last barrier to the junction of these waters must have yielded, and for the first time the Atlantic ebbed and flowed in the ancient depression south of the Devon and Cornwall coasts, now re-excavated and largely cleared of the cretaceous deposits. The English Channel may be said to have had its birth.

That the sea still occupied the western part of the Channel during the Oligocene, Miocene, and earlier Pliocene periods seems a fair inference from all known facts, but no evidence for or against this view is yielded by the dredgings. In later Pliocene times the valley of the Channel was once more dry land, and almost certainly drained westward to the Atlantic. There is reason to believe that, during this and the earlier part of the Pleistocene period, features were impressed upon the valley of the Channel which it has never since entirely lost. Despite occasional halts and even retrogressions, the victory has since lain with the sea, which has reoccupied the valley between France and England, and in so doing has modified its contour, bringing into being the Channel bed as it now is.

If the true physical history of the Channel has been as above described, does it explain the conditions now found?

The absence of all actual chalk, excepting some peculiarly hard nodules which from their exceptional character offer great comparative resistance to destructive agents, may be attributed to its removal by solution and denudation during periods of subaerial condition. It may have been that some traces were left which were only finally destroyed by marine erosion during the latest incursion of the sea. It may even be that undiscovered patches yet remain. But the flints are left to indicate where the chalk has been.

Bare patches of soft sandstone and softer marl present no difficulty of explanation. Assuming the last subsidence to have been even

moderately rapid, the shore-line would never have presented any considerable height of cliff. Fringing the cliff in all bays and many creeks would be beaches of sand and shingle derived chiefly from the local rocks. Beyond the beach, where soft strata existed would be tidal plains of marine erosion, such level surfaces as now exist between tide-marks in Torbay. The constant advance of the sea, the constant depression of the land, would ever carry forward the line of shore, the sea-cliff for the time being existent, and the beach would follow; its material would always be largely derived from the actual cliff, but in part consist of older material driven forward by the waves. The rocky plain would sink beneath the sea, and be left as a rather uniform surface of slight gradient seaward. Little or no beach would be left behind, and the older constituents of the beaches, those derived from the outer previous shore-lines, would never long persist, the constant wear reducing and destroying them.

Boulders from harder rocks would not be driven on in the same manner as pebbles and shingle, but would remain near their points of origin. Until, however, some considerable depth of water flowed over them, such boulders would still be liable to wear from exceptional wave action; and, further, we may consider that, especially with the granitoid rocks, submarine weathering must produce, but in a greatly less degree, the familiar effects of subaerial exposure. The chief and important difference would arise from the more uniform temperature of the sea.

There is reason to believe that the first inlet of the sea was somewhat long and narrow, a comparatively sheltered area, where wave action would be slight. That large and relatively unworn stones might be left here would be no occasion for surprise. And as the land sank and the Channel widened, this first-formed portion of its bed would still receive some shelter, until it was covered with water too deep to permit destructive wave-action. Extending the argument, there seems here a reasonable explanation of the general increase in the size of the dredged stony material outward into the Channel. Other causes may have co-operated. That wave action beyond the forty-fathom line has little or no destructive effect upon the pebbles at present, may be judged by the existence of pieces of yellow chalk and of Lias limestone bored and riddled through and through and yet in pebble form.

But in a narrow sea, while the wave action would be slight the tidal currents would be swift, and sand would not readily deposit; hence the fact that these stones were not buried beneath finer deposits derived from the shores.

Even now, could the fine sands which float about in the Channel find a resting-place in its main water-way, a very short period would suffice to bury the stones and boulders. The surface tow-nets used on the cruises undertaken for the purposes of the International Sea Fisheries Investigations constantly catch considerable quantities of fine sand. But sand which by wave disturbance can be maintained at the surface over a depth of forty or fifty fathoms requires but a slight current to prevent it coming to rest on the bottom. It is not necessarily that the currents scour the inorganic sand from the sea-bed, but that they prevent its settlement there.

As regarding organic carbonate of lime, shell, and other material, which is forming even now in the deeper parts of the Channel, the currents must be credited with removing some of this mechanically, some by solution, as the particles become finer by disintegration, and the redeposit of such material must take place in quieter waters. Otherwise from the accumulation of this débris alone the stones would long since have been entirely covered.

Defective argument may be based on accurate observation, and if the hypotheses above put forward are found incapable of bearing the test of closer reasoning or of fresh discovery, the apology for their being must stand—that they are based in fact, and in fact the statement of which has been in no way influenced by them.

On two points further work is in hand: the examination of the flints for fossils, and the closer inspection of the baked shales from the neighbourhood of the presumedly Post-Carboniferous Granite.

AN ADDITIONAL NOTE.—THE SANDS AND GRAVELS.

Fine materials, sands and gravel, from eighteen dredgings have been examined, but not in such detail as might be desirable.

As a whole the mineralogical results confirm the conclusions derived from the stone samples; so closely are these in agreement that a very few points need be noted.

M. 29. S. 14° W. Edd., 19·8 miles, gives exactly the same results in the fine material as in the pebbles, small fragments of the passage-bed marls being fairly frequent, and no Triassic rocks present.

M. 71. S. 23 W. Edd., 19·0 miles, yields Triassic material, which **M. 72,** a coarse dredging from the same spot, did not; this is within the New Red Sandstone area.

M. 75. S. 20° W. Edd., 38·1 miles, yields a little Trias.

M. 65. S. 22° W. Edd., 42·2 miles, possibly contains a little Triassic material.

The southernmost find of New Red Sandstone rocks among the pebbles having been **M. 18, S. 29° W. Edd., 23.4 miles,** this trace of the same in the sands shows in all probability an outward and downward movement of small quantities of detritus, extending nearly twenty miles, certainly fifteen miles. This is the only evidence of any but very restricted movement among the mineral constituents of the sands, and it must be remembered that Triassic sandstones and marls are present in great quantity on their own area, and the amount of detritus would be proportionately large, some might well have trespassed on to other ground.

In all but this matter the inorganic sands agree so precisely with the closely adjacent coarse deposits, even in minute detail, and their constituents are so exactly parallel, that great strength is given to the previously urged view as to the value of the dredgings for approximate geological mapping.

In the gravels of some dredgings sharp chips of brown flints are rather common. Such angular flint flakes were taken at **M. 37, S. 41° W. Edd., 17·1 miles, M. 71, M. 40, M. 73, M. 56, M. 75, M. 76, M. 65,** and **M. 61, S. 25° W. Edd., 46·4 miles,** extending thus over a long range. For the more part the surfaces of the chips are practically undecomposed, and all are of brown flint. (It is black flint which chiefly shows the extreme alteration referred to in an earlier part of this paper.) These chips do not, however, look quite recent. They are such as would be formed by the mutual impact of subangular flints, possibly but rarely of broken flint pebbles. They could never last long on a beach or in any depth of water to which considerable wave action extended, although such wave action might constantly create a fresh supply. With a stationary shore-line a few such chips might be found a little below low-water mark, but only rarely. On the other hand, with an advancing shore-line and constantly deepening water it is quite easy to imagine that, formed on beaches or in shallow water, they might be placed in deeper water conditions soon enough to preserve many of them from destruction. Taking the deposit at Hallsands as an instance of a flint beach, long stationary, I may say that I have never dredged off that shore any such flint chips, although it must be imagined that some are at times formed. But probably one reason for their absence at Hallsands is the extent to which the shingle has been rounded, and a broken pebble is most rarely found; while with the sea advancing over a land surface covered with unrolled flints the process of rounding these into pebbles or commencing such rounding would give rise to very numerous chips. The fragments are therefore the supplement of the subangular blocks of flint still associated with them,

and they persist—firstly, because the original supply was great; secondly, because for some time after their formation the sea was constantly deepening over them; and lastly, those only remain which have formed from material capable of resisting decomposition.

APPENDIX I.

M. Delesse on the English Channel. Translated extract.[1]

"*La Manche*, which washes the whole north-west of France, is a shallow sea, its mean depth being no more than 45 metres. Its basin shoals near the coasts of France and England, and also toward the *Pas-de-Calais*, while deepening toward the Atlantic.

"We would direct attention to the submarine terraces which border the coasts as among the principal features of the orography of *la Manche.* Outside these terraces somewhat numerous banks occur, especially toward the *Pas-de-Calais*, as, for instance, the *Bassure*, the *Vergoyer*, and the *Colbart*, which lie near and parallel with the French coast.

"Note should be made of the central deep which stretches from off the county of Sussex to *Finistère.* Near *cap de la Hague*, at the western extreme of *Cotentin*, it twists and presents irregular ramifications.

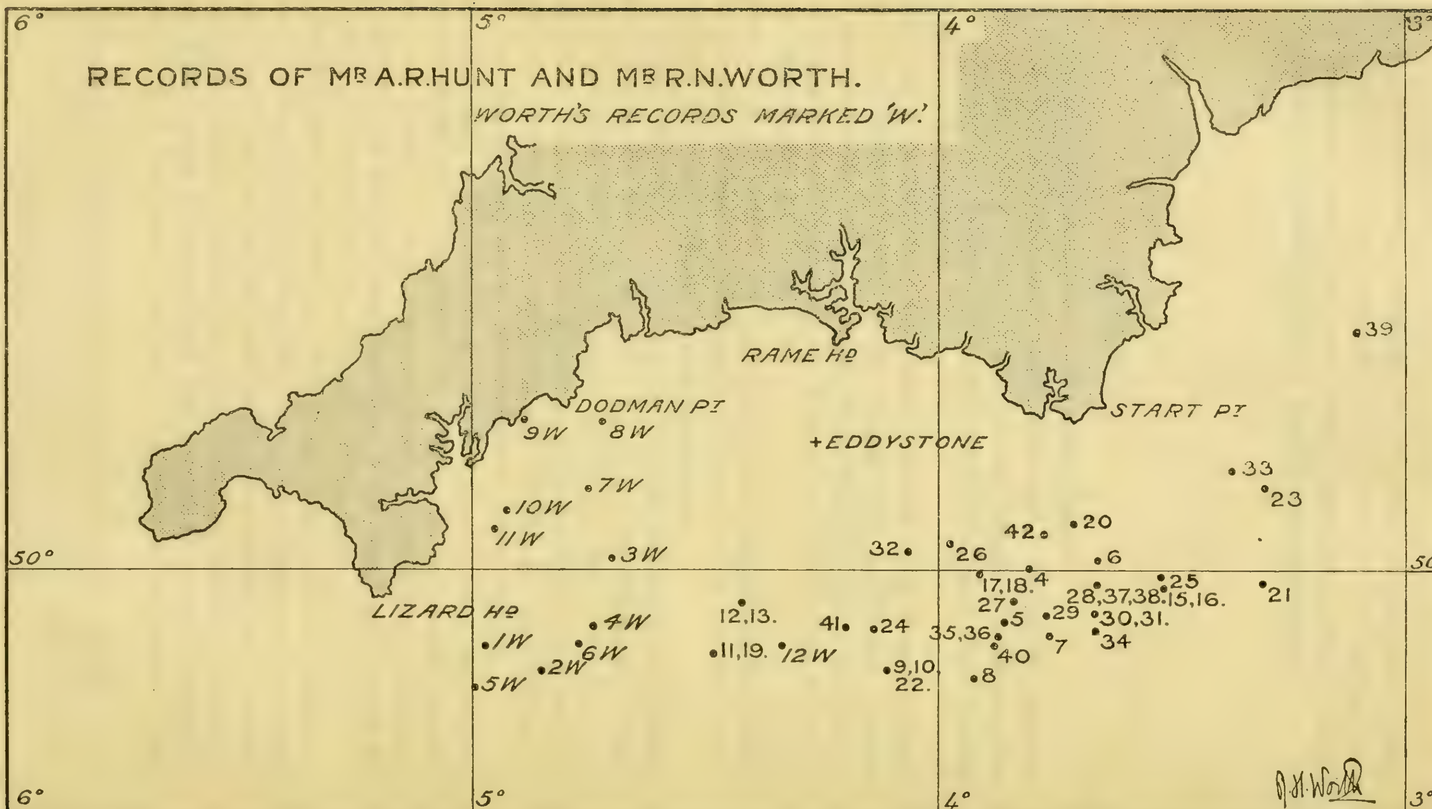
"In breadth but slight, in depth it much exceeds the rest of *la Manche*, reaching even, at the west of *cap de la Hague*, to over 160 metres. This central deep corresponds to a submarine valley, and that it has not been scoured out by the currents of *la Manche* its characteristics clearly show. It is formed, on the contrary, by a deep cleavage, having a general direction of E.N.E., and, although very narrow, not yet filled by recent deposits.

"Since *la Manche* is swept by strong currents, it should follow that deposits are not universally received on its bed, which, on the contrary, should frequently be formed of rocks (*roches pierreuses*) of earlier than the present period; and this, in fact, the soundings show, while these rocks occupy an even greater proportional area of the bed than in other seas.

"In the first place, they cover large areas in the western part of *la Manche;* they border Brittany and Cotentin, which they join to Jersey and the other Channel Islands; and further they unite Brittany to Cornwall, and Cotentin to the south of England. Cutting out on very irregular boundaries, not only do they spread along the coasts, but pass completely across *la Manche*, extending even to the deepest parts of its basin and the mid-course of its valley.

"These rocks are certainly very varied; between Brittany, Cotentin, and Cornwall and Devonshire, they are, however, either granites, or belong to the

[1] *Lithologie des Mers de France*, etc., p.p. 308–9.


RECORDS OF MR A.R.HUNT AND MR R.N.WORTH.
WORTH'S RECORDS MARKED 'W.'
6°
5°
4°
3°
50°
RAME HD
DODMAN PT
START PT
+EDDYSTONE
LIZARD HD
9W
8W
7W
10W
11W
3W
4W
1W
6W
2W
5W
12W
12,13.
11,19.
41
24
32
26
42
20
6
39
33
23
21
25
17,18.
4
27
5
28,37,38.
15,16.
29
30,31.
34
35,36.
7
40
8
9,10.
22.
R.H. Worth

To face p. 179.

transition formations. Soundings show that they consist in part of detached stones (*pierres désagrégées*); in addition to which rotten rocks (*roches pourries*) are frequent around latitude 49° 15′, longtitude 7° 10′ (W. of Paris), in the mld-course of the valley of *la Manche.*

"Further to the east the rocks should be submarine extensions of the secondary formations which build up the opposite coasts of France and England. Thus the coast rocks of *Calvados*, which are limestones of the lower Jurassic period, are continued far out under the sea. And, similarly, white chalk is found at a considerable distance from the chalk cliffs of *Fécamp*, of *Dieppe*, and of *Saint-Valery en Caux*, and is especially prominent on the bed of the *Pas-de-Calais*," etc.

APPENDIX II.

By the kind permission of Mr. A. R. Hunt, M.A., F.G.S., the following petrological notes, abstracted from his papers on the Submarine Geology of the English Channel[1] are here reproduced.

In his work, Mr. Hunt had the assistance of the late Mr. E. B. Tawney, M.A., F.G.S. (E. B. T.), Prof. T. G. Bonney, M.A., F.G.S. (T. G. B.), and Mr. A. Harker, M.A., F.G.S., (A. H.), and all the notes herein included are taken from the descriptions written by some one or other of these petrologists.

The initials of the authorities, as given above, follow each entry.

Although for present purposes the notes have been somewhat shortened, no variation has been made amounting in any way to more than the exclusion of minor detail.

All bearings are magnetic, and bearings and distances alike are given on the authority of the fishermen who trawled the blocks. Hence minute accuracy can not be expected, but, on the other hand, subsequent experience indicates that probably no very considerable error has been made. (Plate XVII.)

CRYSTALLINE ROCKS.

Eight Granite. Nos. 2, 19, 20, 27, 34, 35, 39, 42.

H. 2. Doorstep of Brixham Orphanage. A granite of moderately coarse grain and pinkish colour, with large pale flesh-coloured orthoclase twins.

Biotite and muscovite in about equal proportions. Orthoclase largely predominant, but some plagioclase present.

The quartz contains cavities, some with moving bubbles; also microlite needles, and hair-like delicate crystals of undetermined character. Some apatite is present.—E. B. T.

[1] *Transactions of the Devonshire Associations*, 1879, 1880, 1881, 1883, 1885, 1889.

H. 19. Broken off by trawl about 20 miles S.W. of Eddystone.

Granite of coarse grain. Both white and black micas present. A little triclinic felspar in addition to the orthoclase. The quartz contains large fluid inclusions with bubbles. Apatite is abundant in rather large crystals.—E. B. T.

H. 20. About 10 miles S.W. by S. of Start Point, weight about 15 to 16 cwt.

A coarse grey granite with silvery mica in addition to dark mica. Felspar chiefly orthoclase, but a little triclinic felspar, including microcline, is present. The quartz contains fluid cavities. An occasional tendency to micropegmatic structure.—E. B. T.

H. 27. Trawled 18 miles S.W. of the Start.

A rather fine-grained granite, reminding Prof. Bonney somewhat of granites from one or two localities in the Channel Isles.

It consists of quartz, felspar (orthoclase, oligoclase (?), and perhaps microcline), and two micas, black and white, the former occasionally somewhat altered.—T. G. B.

H. 34. Trawled 18 to 20 miles S.S.W. of Start Point. Weight 9 or 10 cwt.

A true granite, a good deal decomposed.—T. G. B.

H. 35. Trawled 21 miles S.W. of Start Point. Weight about 5 cwt.

A granite containing quartz, with the usual felspars, hornblende, and brown mica.—T. G. B.

H. 39. Trawled 15 miles S.E. by E. of Berry Head. Weight 4 to 5 cwt.

A rather fine-grained granite of a warm greyish colour. It consists of quartz, —containing fluid cavities, with bubbles and some acicular microliths (?rutile) —felspar, somewhat decomposed, both orthoclase and plagioclase (?oligoclase), brown mica, occasionally somewhat decomposed, a little white mica, and iron oxide.—T. G. B.

H. 42. Trawled 12 miles S.W. of Start Point. Weight 3 cwt.

A moderately finely crystalline rock, speckled lighter and darker grey, looking like a granite, with possibly a slight foliation. Consists of quartz, felspar (orthoclase and plagioclase), and a considerable quantity of brown mica, with a rich colour and strong dichroism. Now and then there is a little white mica.—T. G. B.

Four Hornblendic Granite. Nos. 4, 21, 24, 25.

H. 4. Trawled 15 miles S.W. of Start Point. A rounded block measuring 3′ 6″ × 2′ 3″ × 1′ 8″.

A coarse-grained rock, exhibiting colourless felspar and quartz, black hornblende, and brown mica. Hornblende and biotite abundantly present. Of the felspars, orthoclase and plagioclase seem in almost equal proportions; both are much decomposed and kaolinised in patches. The quartz contains a quantity of hair-like crystals of undetermined nature; besides these are a

few prismatic microlites, and enclosure of minute cavities. Apatite is well developed also.—E. B. T.

H. 24. Trawled 14 or 20 miles S.S.E. of Start Point. Weight about 4 cwt.

A rather coarse-grained hornblendic granite, of darkish tint; the felspars of slightly pinkish hue. Both hornblende and dark mica are present in abundance. The felspar is much decomposed, and is chiefly orthoclase. Apatite present.—E. B. T.

H. 21. Trawled 16 or 17 miles S. of Eddystone. Weight about 5 cwt.

A granite of medium grain, with faint pink-tinted felspars, and in which hornblende is abundantly visible; of biotite there is much less. Though the felspars are much decomposed, plagioclase can be detected in some quantity. Apatite seems nearly absent. Quartzes are clear, but moving bubbles are frequent in the liquid inclusions.—E. B. T.

H. 28. Trawled 15 miles S. of Start Point. Weight 3 to 4 cwt.

To the eye much like No. 24, but differs a little in shade. Biotite more abundant than hornblende; apatite very abundant.—E. B. T.

One Gneiss. No. 36.

H. 36. Trawled about 21 miles S.W. of Start Point. Weight 8 or 9 cwt.

Quartz, felspar (plagioclase predominating), brown mica and some white mica, apatite. Prof. Benney adds: "The rock, I think, is undoubtedly a gneiss, and it is of an Archæan type."—T. G. B.

Three Granitoid Gneiss. Nos. 3, 28, 61.

H. 3. Salcombe Block, buried at Brixham Orphanage.

A rather fine-grained granite-looking rock, in which a certain streaky arrangement of the mica is apparent, the felspars fresh and translucent.

The thin slice shows the micas distinctly set in one direction mainly; they wrap around the felspars or larger quartzes. The felspars show little or no kaolinisation; orthoclase more abundant than plagioclase. Both biotite and muscovite are present. The quartz contains numerous delicate, long capillary crystals, and cavities with bubbles. Apatite is present.—E. B. T.

No. 28. Trawled 15 miles S.S.W. of Start Point. Weight 12 cwt.

A very coarse gneiss rather than a granite. The quartz occurs both in larger grains, rather full of cavities, and in aggregates of small granules. The felspar is in parts more decomposed, and replaced by aggregates of secondary products (micaceous and other microliths), or by a dull greenish granular mineral, perhaps an impure epidote, but in parts is fairly well preserved, microcline being common. There are also flakes of an olive-brown older mica, and a few granules of iron peroxide. "This rock has the aspect of a very ancient Archæan gneiss."—T. G. B.

H. 61. Erratic on shore, S.E. of East Prawle.

A light grey rock with the appearance of a fine-grained granite or granitic gneiss. The foliation seen in the slice is not evident in the hand-specimen.

The rock consists mainly of felspar and quartz, with subordinate biotite, etc. The felspar is chiefly, if not wholly, of triclinic varieties. Much of it is microcline; there is also some oligoclase with carlsbad, and albite-twinning. Most is clear, but there are cloudy patches in places, which seem due to the development of white mica in minute scales. Quartz occurs in large and small grains, usually composite; strain-shadows are common. The biotite has a marked parallel orientation throughout the slice. It is a deep brown, intensely pleochroic mica, becoming green only by alteration. The other elements of the rock are rare magnetite and green hornblende, with some epidote and other secondary minerals.—A. H.

Two Hornblendic Gneiss. Nos. 33, 44.

H. 33. Trawled about 12 miles S.E. of Start Point.

Quartz abundant in irregular aggregated granules, felspar in occasional grains, with very irregular outline; orthoclase (probably) and plagioclase. Green hornblende, a strongly dichroic variety, in streak-like aggregates of long, slightly fibrous prisms, magnetite, a few films of brown mica, a little apatite, possibly zircon.—T. G. B.

H. 44. Trawled block, lying on Brixham Quay.

A medium-grained felspar-hornblende rock with well-marked banding, the white felspathic and black hornblendic bands being commonly from one-twentieth to one-eighth inch in width. There is no evident fissile structure, and the rock is perhaps to be styled a hornblende-gneiss rather than a hornblende-schist.

Felspar, the dominant mineral, is exclusively plagioclase, apparently a basic labradorite. Inconstant twinning is often seen to be clearly connected with a slight bending of the crystal, and must in great part be secondary and the consequence of strain. Most of the felspar is perfectly clear, but there are also cloudy opaque patches, white by reflected light. The abundant green pleochroic hornblende is in ragged or irregularly bounded crystals. Associated with it is a clear colourless augite. This is often embedded in the hornblende, but there is no clear indication of the latter mineral having originated at the expense of augite. No iron-ore appears in the slice.—A. H.

Three Hornblendic Granitoid Gneiss. Nos. 31, 32, 41.

H. 31. Trawled 18 miles S.S.W. of Start Point. Weight about 3 cwt.

Quartz, felspar, brown mica, a little hornblende, and a little green chloritic mineral, perhaps an alteration product after some of the mica, some apatite. The quartz has rather numerous minute cavities, some empty, some with small moving bubbles. The felspar (which is a little decomposed) is partly orthoclase, but there is a good deal of albite or oligoclase.—T. G. B.

H. 32. Trawled 12 miles S.S.E. of Eddystone. Weight about 7 cwt.

Minerals as in 31, but in rather different proportions. For instance, there is more hornblende. The state of preservation is not so good.—T. G. B.

H. 41. Trawled 16 miles S. by W. of Eddystone. Weight 5 to 6 cwt.

A pale-coloured coarse rock with a rather porphyritic structure, the felspar crystals occasionally about an inch long. Quartz containing rather numerous enclosures, chiefly little cavities with small bubbles; felspar, rather decomposed, one crystal in the section is a plagioclase, but the larger crystals resemble orthoclase; white mica; the section shows a good-sized grain of brownish hornblende; some dark granules or grains, probably hematite.—T. G. B.

One Microgranulite. No. 40.

H. 40. Trawled 22 miles S.W. of Start Point. Weight 2 or 3 cwt.

The ground-mass a very intimate mixture of quartz and felspar, exhibiting numerous varieties of micrographic structure. Rather rounded crystals of felspar, up to about quarter of an inch in diameter, generally in fair preservation, and in most cases orthoclase. Smaller and less distinct grains of quartz. Irregular patches of a dark mineral, seen in the section to be a green chloritic mineral, often rendered nearly opaque by the association of brown iron oxide.—T. G. B.

One Quartz Felsite. No. 43.

H. 43. Exact locality unknown. Weight about 12 cwt.

The microscope shows grains of quartz and felspar, and clusters of rather small flakes of biotite, scattered in a microgranular matrix of quartz and felspar, with occasional flakes of biotite or a greenish mineral, possibly a chlorite or a variety of hornblende, with sometimes a certain amount of ferrite staining. The felspar varies much in its state of preservation, some grains being very decomposed, others rather clear. Plagioclase is present.—T. G. B.

Two Syenite. Nos. 7, 9.

H. 7. Trawled about 20 miles S.W. by W. of Start Point. Weight about 4 cwt.

A dark green rock of coarse grain, felspars opaque, tinted with pale green and mixed with black hornblende in about equal proportions. Microscopic examination shows the felspars so much decomposed that they are not individually determinable; many are certainly plagioclase from indications of multiple twinning, whether plagioclase or orthoclase is predominant cannot be determined. There is a considerable amount of quartz present, of which much is certainly secondary; it is seen replacing felspar crystals and originating from their decomposition. The hornblende is green in colour; by decomposition it gives rise to chloritic matter, with which some epidote is mixed; epidote may also be seen in the decomposed felspars. Apatite crystals are large, and specially abundant near the hornblende. Ilmenite is also present.—E. B. T.

H. 9. Dredged 20 miles S. of Eddystone. Weight from $\frac{1}{4}$ to $\frac{1}{2}$ cwt.

The same minerals occur as in No. 7, but it differs by the abundance of quartz, the substitution mostly of chlorite for hornblende, and the obscure linear arrangement of the same.—E. B. T.

Four Diorite. Nos. 1, 16, 22, 62.

H. 1. From Salcombe fishing grounds. Weight $9\frac{1}{4}$ cwt.

Macroscopically this rock shows a pale yellowish-white felspar and a very dark green hornblende, which appear to be rather closely set in a dull yellow-grey rather compact matrix. The slide shows felspar crystals, which have a tolerably regular outline, but are, as a rule, much decomposed, the mineral being often converted into an aggregate of earthly granules. In some of the crystals the polysynthetic twinning of plagioclase is still visible. The hornblende is a rich green colour, with fairly strong dichroism, and tolerably perfect crystal outlines. There are several grains of quartz, and a few clusters of small flakes of brownish mica, and a little magnetite.—T. G. B.

H. 16. Trawled 17 miles S. of Start Point. Measures $2' 6'' \times 1' 10'' \times 1' 2''$.

A sap-green coloured rock, in which the large actinolite crystals chiefly catch the eye; it is coarsely crystalline. The microscope shows the long actinolite crystals, green in colour, and at the borders often connected with diverging bundles and needles of pale green crystals, also actinolite, which penetrate the felspars.

The plagioclase still preserves its twinning for the most part, but much of it is attacked by decomposition, and it is everywhere permeated by long actinolitic fibres and particles. Apatite is present. Secondary quartz has been deposited in little veins and interstices.—E. B. T.

H. 22. Trawled 20 miles S. of Eddystone. Weight about 5 cwt.

Quartz is not so abundant as in granite, while the microscopic examination shows that the prevailing felspar is triclinic. Hornblende is abundant, and also dark mica; the latter occurs not so much as scattered crystals as in groups of diverging or matted prisms. Apatite is abundant; magnetite grains occur also mixed with the mica.—E. B. T.

H. 62. Erratic on shore near Gorah Run, E.S.E. of Prawle.

A moderately coarse granitic rock, in which black hornblende is conspicuous, set in white felspar and grey quartz. Lustrous flakes of dark mica are also seen.

Green hornblende and brown biotite are both well represented. The former often shows faces of the prism-zone, but never builds very perfect crystals. One section, three-eighths inch in diameter, is studded with little grains and rounded crystals of felspar, and some of quartz. The smaller crystals of hornblende are sometimes twinned on the usual law. Much of the biotite, which tends to build stout flakes, is bleached and partially decomposed. The felspar tends to form rectangular crystals, and is chiefly, if not wholly, oligoclase with rather close albite-lamellation. The crystals are often cloudy from alteration, especially in the interior. The clear quartz often shows strain-shadows. The only other original mineral is a little apatite.

Quartz is more abundant than in most ordinary quartz-diorites.—A. H.

TWO DIABASE. Nos. 17, 37.

H. 17. Trawled 17 to 18 miles S.W. by W. of Start Point. Weight 7 to 8 cwt.

A dark green rock of medium grain, with minute specks of pyrites. A diabase of ordinary type. The plagioclase is much decomposed, the twinning being often lost. Quartz has been secondarily deposited. The augite has also been partly attacked by decomposition, and chloritic matter has resulted thereby. A little apatite is present. Magnetite or black oxide is much more abundant than the pyrites.—E. B. T.

H. 37. Trawled 15 miles S.S.W. of Start Point. Weight 7 to 8 cwt.

A rather compact, dull, greenish-grey crystalline rock. Microscopic examination shows it has once been a fine-grained but holocrystalline rock, composed mainly of plagioclase felspar, augite, and some iron peroxide; but it is now composed of more or less altered felspars, associated with viridite and chloritic minerals, epidote and other secondary products, and perhaps some altered augite.—T. G. B.

THREE GABBRO. Nos. 8, 15, 38.

H. 8. Trawled about 25 miles S.W. of Start Point. Weight 5 to 6 cwt.

A coarse-grained rock consisting of white opaque felspar crystals and yellowish-grey diallage. Microscopic examination shows no other constituents; the felspar is almost entirely decomposed, scarcely showing original optical features. The diallage at borders sometimes undergoes a change into actinolite.—E. B. T.

H. 15. Trawled about 16 miles S. of Start Point. Measures 2′ 8″ × 1′ 8″ × 1′ 6″.

To this block some 'killas' was adherent, so that it was a junction specimen. The diallage scarcely retains its own physical properties; much of it has become altered to an aggregate of diverging fibrous, colourless or pale greenish crystals, which may probably belong to the actinolite group. The plagioclase is in places opaque from decomposition, and is everywhere much penetrated by the pale green actinolite microlites.—E. B. T.

H. 38. Trawled 15 miles S.S.W. of Start. Weight 10 cwt.

A moderately coarse-grained compound of a bluish-white felspar and a dull green mineral. Microscopic examination shows that it is a considerably altered gabbro. The plagioclastic felspar is to a very large extent replaced by micromineral products, such as occur in the so-called saussurite. The augite or diallage is replaced by hornblende, sometimes normal in aspect, sometimes rather actinolitic. An iron oxide and a little apatite are present, but no indication of former olivine.—T. G. B.

ONE SERPENTINE. No. 6.

H. 6. Trawled 13 miles S.S.W. of Start Point. Weight 5 cwt.

Mottled red and green colour, with steatite veins, and precisely like some of the Cornish varieties.

The microscope shows that none of the olivine is left unchanged in the meshes; in the serpentine are abundance of scattered hæmatite blotches. Veins of chrysolite, or steatite, have a central line of black iron oxide bordered often with red. Some of the enstatite is left unchanged, but only in fragments in the middle of bundles of talcose crystals and steatite, to which it seems to give rise by decomposition.—E. B. T.

One Trachyte. No. 29.

H. 29. Trawled 18 miles S.W. by S. of Start Point. Weight 3 or 4 cwt.

Under the microscope this rock exhibits a glassy base, in part but probably not wholly devitrified, with a fairly well-marked fluidal structure. It has undergone a certain amount of secondary change in the development of various microlithic minerals, showing bright colours between crossed nicols, and of specks of viridite. In this ground-mass occur numerous crystals of felspar, sometimes rather rounded or broken-looking, which contain microliths or glass inclusions, more or less altered. Some are plagioclase, probably oligoclase, others appear to be orthoclase. There is a filmy green mineral associated with streaks of opacite, which very probably replaces a mica, and there are some grains of iron peroxide. No quartz grains are to be seen in the slide; there may be some apatite.—T. G. B.

NON-CRYSTALLINE ROCKS.

Two Conglomeratic-grit. Nos. 5, 26.

H. 5. Trawled 20 miles S.W. of Start Point. Weight 10 cwt.

A coarse grit containing a few pebbles of rolled vein quartz, flesh-coloured felspar, and fragments of fine-grained felsite-like rock. The rock has much the appearance of an arkose.—E. B. T.

H. 26. Trawled 15 or 20 miles W.S.W. of Eddystone. Weight 3 or 4 cwt.

A moderately coarse grit composed wholly or almost wholly of rounded grains of whitish quartz, cemented by pyrite.—T. G. B.

One Killas. Attached to No. 15.

H. 15. Trawled 16 miles S. of Start Point.

One Triassic Sandstone. No. 10.

H. 10. Trawled 20 miles S. of Eddystone.

An unrolled fragment of a reddish-brown sandstone, similar in appearance to the Triassic sandstones abundant either in mass or as outliers on the coast of South Devon.

One Neocomian Sandstone. No. 23.

H. 23. Trawled 15 miles S.E. of Start Point. Weight 9 to 10 cwt.

A sandstone with green grains; it has all the appearance of Neocomian sandstone, as in Kent.—E. B. T.

FOUR (SETS) CHALK FLINTS. Nos. 11, 12, 14, 18.

H. 11. Trawled 20 miles S.W. of Eddystone.

Some twenty chalk flints; one weighs 6 lb., and is perfectly unrolled.

H. 12. Trawled 15 miles S.W. of Eddystone.

A small flint about 8 oz. in weight.

H. 14. Trawled 20 miles S.W. of Start Point. Weighs 3 lb. 2 oz. and 2 lb. 14 oz. respectively.

H. 18. Trawled 17 or 18 miles S.W. by W. of Start Point. One flint weighed 1 lb. 9½ oz.

ONE LIMESTONE. No. 13.

H. 13. Trawled 15 miles S.W. of Eddystone.

A small piece of buff-coloured limestone, riddled through and through by molluscs and other marine borers.

ONE GRIT. No. 30.

H. 30. Trawled 15 to 20 miles S.S.W. of Start Point.

This is a small stone, measuring about 8″ × 6″ × 4″, of fine grit, and may well have been used for ballast. Its evidence is accordingly valueless.

APPENDIX III.

THE observations of the late Mr. R. N. Worth,[1] F.G.S.

The bulk of the material was obtained for Mr. Worth by the late Mr. Matthias Dunn, of Mevagissey; it was all brought up entangled in the hooks of bolters or long-lines. All bearings are magnetic. (Plate XVII.)

"The evidence that the rocks were *in situ* when entangled (partly by the marine growths upon them, and partly by their irregularities and the holes bored by *Pholades*) is clear. With two exceptions only, the specimens retained the characteristics of the original bedding."

W. 1. S.E. Lizard, 10 miles.

Fine-grained, soft, red Triassic sandstone, in layers 1½ to 2 inches thick.

W. 2. S.E. Lizard, 15 miles.

Triassic sandstone of coarser grain, mottled red and grey.

W. 3. S.E. Manacles Rocks, 16 miles.

Fine-grained soft sandstone, grey with a passing tinge of red in places, in parts highly micaceous, containing both black and white micas.

W. 4. S.S.E. Falmouth Castle, 18 miles.

Fine-grained, compact, red, jaspideous sandstone, much bored. The specimen shows portions of two joint faces, at right angles to each other.

W. 5. S.W. by S. Deadman, 25 miles.

a. Chocolate marl, spotted white. The edges of this nodule were rounded, but it could hardly be called rolled.

[1] *Quarterly Journal of the Geological Society*, Vol. XLII, 1886, pp. 313–15.

b. A "Potato Stone," partially coated with marl and filled with pinkish calcite. The inside of the shell was studded with small brilliant pyramids of quartz.

c. Grey sandstone.

d. A nodule of Triassic Trap. A hard red rock, slightly micaceous; very closely resembles some varieties of the Triassic Trap of Thorverton, with affinities to those of Pocombe and Cawsand.

W. 6. S. by W. Deadman, 20 miles.

a. A light salmon-tinted drab calcareous sandstone, in a slab nearly two feet in longest diameter, the under surface intact and slightly pitted.

b. Granitic and granitoid pebbles.

c. Quartzite pebbles.

d. Flints.

W. 7. S. Deadman, 7 miles.[1]

Slabs of Triassic conglomerate, evidently torn from a submarine reef-point, sides, and upper and lower surfaces being intact in each instance, and the only broken surface that of fracture from the parent rock. Examined microscopically this conglomerate proves to contain pebbles of slate, grits, vein quartz, quartz-felsite, and andesite.

W. 8. S.E. Deadman, 3 miles.

W. 9. W. Deadman 4 miles.

W. 10. S.W. Deadman, 10 and 12 miles.

W. 11. S. by E. Deadman, 27 miles.

No Trias found at any of the last four positions.

W. 12. S.W. Falmouth, 10 miles.

Ochreous volcanic ash.

[1] "Additional Notes on the Cornish Trias," *Trans. Royal Cornwall Geological Society*, 1891.

EXPLANATION OF PLATES.

Plate VI. (Opp. p. 123). (1). Micro-pegmatite, with characteristic intergrowth of felspar and quartz. (2). Central portion of (1), more highly magnified.

,, VII. (Opp. p. 135). (1). Hornblende-gneiss. Showing 3 garnets; immediately beneath the central one a small, uniformly tinted area of chlorite. (2). Chlorite schist with crushed plagioclase felspar.

,, VIII. (Opp. p. 143). Grit, with derived fragment of older rock (A–B).

,, IX. (Opp. p. 151). (1). Hard yellow chalk, with derived inclusion of earlier chalk rock. (2). Section of same, showing foraminifera, shell fragments and other organic remains.

,, X. (Opp. p. 153). Decomposed black flint, with shell fragments and complete foraminifera in carbonate of lime. (2). Lower part with carbonate of lime removed.

,, XI. (Opp. p. 156). Eocene limestone.

,, XII. (Opp. p. 157). Eocene limestone, showing foraminifera.

,, XIII. (Opp. p. 163). Chart, Start to Hand Deeps. Illustrating Dr. Allen's Start-Eddystone dredgings.

,, XIV. (Opp. p. 166). Chart showing distribution of granite and gneiss.

,, XV. (Opp. p. 168). ,, ,, ,, trias, rhaetic, and lias.

,, XVI. (Opp. p. 169). ,, ,, ,, hard yellow chalk.

,, XVII. (Opp. p. 179). ,, ,, location of dredgings recorded by Mr. A. R. Hunt and Mr. R. N. Worth.

The Schizopoda and Isopoda collected by the "Huxley" from the north side of the Bay of Biscay, in August, 1906.

By

W. M. Tattersall, M.Sc.

I AM indebted to the courtesy of Dr. Allen for the opportunity of examining the collections of these two orders of Crustacea in the *Huxley's* material.

None of the species are new to science, and but few of them present any features worthy of remark. The chief interest of the collection lies in its bearing on the known geographical distribution of the species captured for, out of a total of twenty-eight, no fewer than sixteen are recorded for the first time from localities south of the British Islands, while only eight of the species have previously been recorded from the Bay of Biscay. The bathymetrical range of five of the species recorded has been considerably increased by this material.

A comparison of the following lists with those for the same orders collected by the *Caudan* expedition, reveals little that is common to the two, the explanation of which is probably that the *Caudan* was working in much deeper water and considerably south of the area explored by the *Huxley.* The results of the work done by the *Hirondelle* and the *Travailleur* and *Talisman* in the Bay of Biscay are not available for the orders now under consideration. The only other expedition which has worked in the Bay is the *Research*, but as that dealt entirely with plankton, the results are not strictly comparable with those of the *Huxley.*

List of Species and the stations at which they occurred.

Station	II	V	VII	VIII	IX	X	XI	XII	XIII
Longitude, N.	48°24′	47°48′	47°36′	47°30′	48°7′	48°7′	48°10′	48°7′	48°7′
Longitude, W.	6°28′	7°46′	7°31′	7°31′	8°13′	8°13′	8°11′	8°13′	8°13′
Fathoms	75	109	111	Surface	240	Surface	146	246	412
SCHIZOPODA.									
Euphausia Mülleri	–	–	–	ca. 1000	–	28	–	–	–
Meganyctiphanes norvegica	–	–	–	5	–	ca. 300	–	22	–
Nyctiphanes Couchi	–	–	–	–	–	ca. 200	–	–	–
Nematoscelis megalops	–	–	–	2	–	32	–	–	–
Lophogaster typicus	–	2	–	–	2	83	1	–	–
Siriella norvegica	–	3	–	–	–	–	7	–	–
Haplostylus Normani	–	–	–	–	–	26	–	–	–
Anchialina agilis	–	–	–	–	–	38	–	–	–
Amblyops abbreviata	–	–	–	–	–	–	–	31	–
Paramblyops rostrata	–	–	–	–	1	–	–	–	–
Pseudomma affine	–	–	–	–	–	–	–	3	–
Mysideis insignis	–	–	–	–	1	–	–	36	–
Mysidopsis didelphys	–	1	–	–	–	–	–	–	–
Leptomysis gracilis	–	–	–	–	–	1	–	–	–
Leptomysis sp.	–	–	–	–	–	–	2	–	–
Mysidetes Farrani	–	–	–	–	–	–	–	4	–
Boreomysis arctica	–	–	–	–	–	–	–	3	–
Schistomysis ornata	–	10	–	–	–	–	3	–	–
ISOPODA.									
Aega Strömii	–	–	–	–	–	–	–	3	–
Rocinela damnoniensis	–	–	–	–	1	–	–	4	–
Cirolana borealis	1	1	–	–	4	–	–	12	–
Cirolana Hanseni	–	–	–	–	–	–	–	–	1
Eurydice truncata	–	–	–	–	–	53	–	–	–
Astacilla longicornis	1	–	–	–	–	–	–	16	1
Ianira maculosa	–	–	5	–	–	–	–	–	13
Munna Boecki	–	–	2	–	–	–	–	–	–
Eurycope longipes	–	–	–	–	–	–	–	3	–
Aspidophryxus peltatus	–	1	–	–	–	–	–	–	–

SCHIZOPODA.

Of the eighteen species of this order represented in the collection, none can be described as new, though two specimens of the genus *Leptomysis* cannot be referred satisfactorily to any described form. They are, however, very closely allied to *L. gracilis*, and I await further material before deciding the point. The depth at which they were found is unusual for the genus.

Only four of these species have been previously recorded from the Bay of Biscay, viz., *Euphausia Mülleri*, *Meganyctiphanes norvegica*, *Nematoscelis megalops*, and *Lophogaster typicus.*

Four other species, *Nyctiphanes Couchi*, *Haplostylus Normani*, *Anchialina agilis*, and *Boreomysis arctica* are, however, known from

the Mediterranean, and their occurrence in the Bay of Biscay merely fills, in part, the gaps existing in their geographical distribution. The remaining species have not hitherto been recorded from localities south of the British and Irish area (*Leptomysis gracilis* is, however, known from the French side of the English Channel). The majority of them are deep water forms, which recent work has shown to be more or less abundant off the west coast of Ireland on the fringe of the Atlantic slope, and it was only natural, therefore, to expect that their known distribution would be considerably extended when the slope was further explored to the south.

Siriella norvegica and *Schistomysis ornata* are here recorded from depths greater than any at which they have up till now been taken, while the capture of no fewer than one thousand specimens of *Euphausia Mülleri* and eighty-three of *Lophogaster typicus* in surface hauls are features worthy of special note.

The records of *Paramblyops rostrata* and *Mysidetes Farrani* are of interest, since these two species have only lately been described from material collected in deep water off Ireland.

SCHIZOPODA.

Family EUPHAUSIIDAE.

Euphausia Mülleri, Claus.

Station VIII. *ca.* one thousand specimens, up to 22 mm.

Station X. Twenty-eight specimens, 5–11 mm.

The occurrence of no fewer than one thousand specimens of this species in a surface haul, Station X, is worthy of special note.

Meganyctiphanes norvegica (M Sars).

Station VIII. Five specimens, 14–28 mm.

Station X. *ca.* three hundred specimens, 11–33 mm.

Station XII. Twenty-two specimens, 17–34 mm.

Nyctiphanes Couchi (Bell).

Station X. *ca.* two hundred specimens, 7–17 mm.

Nematoscelis megalops, G. O. Sars.

Station VIII. Two specimens, 10 and 11 mm.

Station X. Thirty-two specimens, 10–18 mm.

Family **LOPHOGASTRIDÆ.**

Lophogaster typicus, G. O. Sars.

Station V. Two females, 20 and 22 mm.
Station IX. Two females, 21 mm.
Station X. Eighty-three specimens, 5–10 mm.
Station XI. One female, ovigerous, 21 mm.

The occurrence at Station X of no fewer than eighty-three specimens of this species in a surface haul is a feature of great interest. *L. typicus* is regarded as essentially a bottom living form, though Holt and Tattersall* have recently recorded a specimen from a haul made at 44 fathoms, over a depth of 136 fathoms. This latter specimen was a gravid female, in which the young were ready to be liberated from the brood pouch. The probable fact is that *L. typicus*, in its normal adult condition, is a true bottom haunting form, but that the female rises to the surface to liberate the young and thus to ensure a wide distribution. The haul at Station X above supports this view, since all the specimens are small, and only two or three of the very largest have assumed quite adult form.

Family **MYSIDÆ.**

Siriella norvegica, G. O. Sars.

Station V. One male, 19 mm.
Two females, 14 and 17 mm.
Station XI. Five males, 17–19 mm.
Two females, 15 and 19 mm.

Haplostylus Normani (G. O. Sars).

Gastrosaccus Normani, G. O. Sars; Middlehavet's Mysider, p. 65; Pls. XXIV, XXV, 1876.

Station X. Fifteen males, 6–8 mm.
Eleven females, 5–11 mm.

These specimens differ in one important respect from the description and figures given by Sars. Without exception, they have the hinder margin of the carapace furnished with two dorsal, upwardly and forwardly, directed lobes. The absence of lobes from the hinder margin of the carapace was one of the characters on which Kossmann separated the genus *Haplostylus* from *Gastrosaccus*. The present examples, however, agree exactly with *H. Normani* in the structure of the antennules, the length, form and armature of the telson, and

* Holt and Tattersall, "Fisheries, Ireland, Sci. Invest., 1904 V., [1906]."

especially in the rudimentary inner branch to the third pleopods of the male and the curiously twisted rami of the second pleopods of the same sex.

It is curious to note in this respect that Holt and Beaumont, writing of *Gastrosaccus sanctus* from the west of Ireland,* remark: "most of the specimens from Bofin have practically no trace of the upturned processes of the hind margin of the carapace, though agreeing in other respects with the type." From these observations it would seem that the presence or absence of lobes is a character which cannot be relied on either for generic or specific separation, but the point is obviously one that requires further investigation. In the meantime, the present specimens agree so well with *H. Normani* in other respects, that I provisionally record them here as that species.

Anchialina† **agilis** (G. O. Sars).

STATION X. Ten males, 6–9 mm.
Twenty-eight females, 6–9 mm., most of them ovigerous.

Amblyops abbrieviata, G. O. Sars.

STATION XII. Fifteen males, 12–16 mm.
Sixteen females, 12–16 mm.

Paramblyops rostrata, Holt and Tattersall.

STATION IX. One female, head and thorax only.

Pseudomma affine, G. O. Sars.

STATION XII. Two males, 11 mm.
One female, 11 mm.

Mysideis insignis, G. O. Sars.

STATION IX. One female, 25 mm.
STATION XII. Ten males, 14–20 mm.
Twenty-six females, 9–22 mm.

Mysidopsis didelphys (Norman).

STATION V. One male, 13 mm.

A specimen of the Isopod parasite, *Aspidophryxus peltatus*, G. O. Sars, was found attached to the basal joint of the left antennule.

Leptomysis gracilis, G. O. Sars.

STATION X. One female, 10 mm.

* HOLT and BEAUMONT, *Sci. Trans. Royal Dublin Soc.*, Series ii., Vol. vii., Pt. vii, 1900.

† *Anchialina*, Norman for *Anchialus*, G. O. Sars. See Norman and Scott, "Crustacea of Devon and Cornwall," London, 1906, p. 24.

Leptomysis sp.

STATION XI. One male, 11 mm.
One female, 11 mm.

These two specimens differed from *L. gracilis* (1) in having the dermis quite smooth instead of hispid; (2) the rostrum is quite short, and does not extend beyond the eyestalks, whereas in *L. gracilis* it is produced into a broadly triangular acutely pointed plate, which extends beyond the middle of the basal joint of the antennules. Otherwise they agree perfectly with normal specimens of *L. gracilis*, and it seems better to await further material before deciding whether they represent a hitherto undescribed form, or are merely abnormal specimens of *L. gracilis*.

Mysidetes Farrani (Holt and Tattersall).

STATION XII. Four females, 18 mm.

Boreomysis arctica (Kröyer).

STATION XII. Two males, 15 and 18 mm.
One female, 14 mm.

Schistomysis ornata (G. O. Sars).

STATION V. Two males, 14 mm.
Eight females, 12–15 mm.
STATION XI. Three females, 14 mm.

Both the stations at which these species occur are over 100 fathoms in depth. This depth is most unusual for the species, the greatest depth at which it has previously been captured being 50 fathoms. I cannot, however, at present find any substantial difference between these specimens and those from shallower water, and I am, therefore, obliged to consider them as belonging to the same species.

ISOPODA.

In all ten species of Isopoda are here recorded from the material collected by the *Huxley*. Of these only four have hitherto been found in the Bay of Biscay, viz., *Cirolana borealis*, *Cirolana Hanseni* (the type specimen of which was dredged by the *Caudan* expedition a little further south of the area explored by the *Huxley*), *Eurydice truncata*, and *Ianira maculosa*.

The remaining six species have not been recorded from localities south of the British and Irish marine area, so that the present records indicate the most southerly limit of their known geographical range.

With regard to the bathymetric range of the species, I am not

aware that *Ianira maculosa*, *Munna Boecki*, and *Astacilla longicornis* have up till now been recorded from greater depths than 400 fathoms, so that the vertical distribution of all three has been extended as a result of the present material. *Ianira maculosa* was only found at Stations VIII and XIII, and from Professor Hickson's report on the *Alcyonaria* of the *Huxley's* cruise it was at both these stations that the majority of the *Alyconaria* were taken. In shallow water *Ianira maculosa* is very frequently found in considerable numbers crawling over colonies of *Alcyonium digitatum*, and in all probability the specimens in the present collection were clinging to the Alcyonarians found on the same grounds. *Eurycope longipes* is a species only recently described from specimens found off the west coast of Ireland on the edge of the Atlantic slope. Its occurrence further south on the same slope, while interesting, is only naturally to be expected.

Family **ÆGIDÆ.**

Æga Strömii, Lutken.

Station XII. Three specimens.

Rocinela damnoniensis, Leach.

Station IX. One specimen.

Station XII. Four specimens.

Family **CIROLANIDÆ.**

Cirolana borealis, Lilljeborg.

Station II. One specimen.

Station V. One specimen.

Station IX. Four specimens.

Station XII. Twelve specimens.

Cirolana Hanseni, Bonnier.

Station XIII. One specimen.

Stebbing, in his report on Professor Herdman's Ceylon Isopoda, suggests that this species should be referred to his genus *Hansenolana*, while Hansen, in his recent revision of the European members of the genus, still retains in it the genus *Cirolana*. The present specimen measures only 3 mm., and is therefore smaller than Hansen's largest specimens, which was 4·2 mm., and which Hansen thought to be still immature. As it is obvious that adult specimens are necessary before the correct genus for the species can be determined, I follow Hansen in retaining it in its original genus, *Cirolana*, for the present.

Eurydice truncata (Norman).

Station X. Fifty-three specimens.

Family ARCTURIDÆ.

Astacilla longicoris (Sowerby).

Station II. One specimen.
Station XII. Sixteen specimens.
Station XIII. One specimen.

Family IANIRIDÆ.

Ianira maculosa, Leach.

Station VII. Five specimens.
Station XIII. Thirteen specimens.

Family MUNNIDÆ.

Munna Boecki, Kröyer.

Station VII. Two specimens.

Family MUNNOPSIDÆ.

Eurycope longipes, Tattersall.

Station XII. Three specimens.

Family DAJIDÆ.

Aspidophryxus peltatus, G. O. Sars.

Station V. One specimen on the basal joint of the left antennule of *Mysidopsis didelphys* (Norman).

Both Sars and myself have recorded this parasite from the antennules of *Mysidopsis didelphys*, while I have also noted it on the same host from the more normal position for such parasites, viz., the dorsal surface of the thorax.

Notes on the littoral *Polychœta* of Torquay.

By

Major E. V. Elwes.

The following notes are confined to the species of Polychæta, which have been found by myself during the last four years, between tide-marks, on the coast comprised within the Borough of Torquay. Torquay is so well known as a hunting ground for the marine zoologist that it is unnecessary to describe the features of the shores. No special study of the Polychæta of Torquay appears to have been previously made, although the locality, Torbay, occurs somewhat frequently in the British Museum Catalogue of Worms.

Syllidæ.

Twenty species of Syllids have been found; of these eight have not apparently been previously recorded from the British area. They are, *Trypanosyllis cœliaca*, Clpd.; *Autolytus ehbiensis*, de St. Joseph; *A. longiferiens*, de St. Joseph; *A. macrophthalma*, Marenzeller; *Grubea clavatu*, Clpd.; *Eurysyllis paradoxa*, Clpd., and *Pionosyllis lamelligera*, de St. Joseph. The Syllids were nearly all obtained by bringing home the roots of Laminaria and placing them in glass vessels, when in a few hours the Annelids crawl out and can be picked out with a pipette.

EXOGONE GEMMIFERA, Pagenstecher. *McIntosh, Mon. Brit. Ann.*, vol. ii., 1908, p. 151; *de St. Joseph, Ann. Sc. Nat. Zool.*, 1886, p. 209 (as *Pœdophylax claviger*).

This species is by no means uncommon at Torquay amongst sea-weeds from half-tide mark downwards. When such weeds are placed in a glass jar, Exogone is one of the first species to leave the shelter of the weeds and crawl out on the glass sides; but unless observed within five or six hours from the time the weed is placed in the vessel, it probably will not be noticed, because it very quickly dies and falls down amongst the debris, where, owing to its small size, it is almost impossible to find it.

The appendages very easily fall off, hence it is not unusual to see individuals with only one or two tentacles.

Females with fully developed young ones, in the seventh stage of de St. Joseph, were found in the month of March.

The young are attached, as de St. Joseph states, to the ventral side by a pedicle; but this pedicle is sufficiently long to allow some movement of the young, so that when the mother crawls about, the young ones turn upwards and appear to be carried on the back.

GRUBEA CLAVATA, Clpd., *de St. Joseph, Ann. Sc. Nat. Zool.*, 1886, p. 200.

One example from Laminaria root, obtained at an unusally low spring tide, from rocks at Oddicombe Beach in the month of January.

PIONOSYLLIS DIVARICATA. Keferstein = *longocirrata*, de St. Joseph, *McIntosh, Mon. Brit. Ann.*, vol. ii., p. 164.

Three or four were obtained in the months of March and April from Corbyn's Head. They were extremely fragile, making it very difficult to prepare a satisfactory mount.

PIONOSYLLIS LAMELLIGERA, de St. Joseph. *Ann. Sc. Nat. Zool.*, 1886, p. 113.

This species is very common, one or more being found in nearly every root of Laminaria. Like P. *divaricata* it is very fragile breaking up into pieces of two or three segments. The Torquay specimens agree with the description given by St. Joseph, but some of them are rather longer, reaching 10 mm. in length and having about 67 segments.

A large proportion of the individuals found were females with ova of a conspicuous pink colour. They often violently vibrate the posterior portion of the body while the front remains fixed. It seems possible that one use of the so-called swimming bristles in the sexual forms of Syllids generally, is to break off a portion, or the bud, from the rest of the body at the proper time.

EUSYLLIS TUBIFEX, Gosse. *McIntosh, Mon. Brit. Ann.*, vol. ii., 1908 p. 173.

Fairly common in glass jars containing weeds covered with Polyzoa and Sertularia, just in the same way as it was first obtained by Gosse at Ilfracombe. Several females containing ova were obtained in the month of April, some of them showing well-developed swimming bristles, but in no case was there any sign of a stolon being formed.

It is curious that a species which is said to be common in the North, and is also found in Devon, should not yet have been reported from the other side of the Channel.

The dorsal cirri rapidly taper to a point, in which respect it appears to differ from *E. Blomstrandi*, which is apparently very near it.

Odontosyllis gibba, Clpd. *McIntosh, Mon. Brit. Annel.*, vol. ii. p. 183.

Several examples of this species were obtained from Corbyn's Head. They agreed in colour with the one from Plymouth figured in *Mon. Brit. Annel.* In one example two red eye-spots in front of the anterior pair of large eyes were distinctly observed. These additional spots apparently have only been previously observed in the *Umbellisyllis fasciata* of M. Sars which, according to McIntosh, is the same species.

Odontosyllis ctenostomata, Clpd. *McIntosh, Mon. Brit. Annel.*, vol. ii., p. 182.

The most abundant of all the species of Syllids at Torquay.

The colour is usually yellowish green. In glass vessels it creeps to the edge of the water. Although unripe individuals are so numerous, only one or two, females, were found with swimming bristles.

Amblyosyllis lineata, Grube. *McIntosh, Mon. Brit. Ann.*, vol. ii., p. 225.

Occasionally met with in weeds from the rocks between Oddicombe and Babbicombe beaches. One individual was marked with purple stripes, and appeared to belong to the variety *formosa.*

Syllis spongicola, Grube = *S. hamata,* Clpd. *McIntosh, Mon. Brit. Annel.*, vol. ii., p. 197.

Fairly abundant. The colour is rather a reddish brown than orange. Several females with ova showed no signs of swimming bristles or formation of a bud. Only one individual showed a distinct bud with ocular spots on each segment.

Syllis prolifera, Krohn. *McIntosh, Mon. Brit. Annel.*, p. 161 (as *Pionosyllis prolifera*).

One of the most numerous of the Torquay Syllids. It appears to be a very variable species, both as regards the number of the articulations of the cirri and the colouring. Some have markings like those given in *Mon. Brit. Annel.*, fig. 53, others like the variety *variegata* as figured by Marenzeller, while some are uniformly coloured.

The articulations of the longer dorsal cirri, in some cases, are as many as fifty. Several with buds were found; one with a regenerated head, without proboscis or proventriculus, exactly like that described by de St. Joseph. *Ann. Sc. Nat.*, 1886, p. 147.

Syllis alternosetosa, de St. Joseph. *Ann. Sc. Nat.*, 1886, p. 150.

The species found at Torquay is undoubtedly the one so fully described by de St. Joseph. Malaquin, in his *Recherches sur les Syllidiens*, considers *S. alternosetosa* as identical with *S. hyalina*, Grube. But this species, as described by McIntosh, *Mon. Brit. Annel.*, vol. ii., p. 167,

differs from it, having all the terminal pieces of the compound bristles bidentate in all the regions of the body.

Giard, on the other hand, as stated on page 202 of *Mon. Brit. Ann.*, vol. ii., considers *S. alternosetosa* as a variety of *S. cornuta*, H. Rathke. The segments in the anterior part of the body are marked with a number of parallel transverse lines, about 20 in number. No buds were seen. Fairly common.

SYLLIS KROHNII, Ehlers. *McIntosh, Mon. Brit. Annelids*, vol. ii., p. 192. *Langerhans, Zeits. für Wiss. Zool.*, 1879, p. 529.

Five examples of this species were found amongst Corallina in a pool in the rocks which jut out from Corbyn's Head. They agreed better with the description and figures given by Langerhans than with those given by McIntosh.

The median tentacle is not shorter than the lateral one, but, as is generally the case with the Syllids, longer, The longer cirri, especially in the anterior part of the body, are also much thicker than the short ones, and somewhat club-shaped. The articulations are well marked. The colouring corresponds to that given in *Mon. Brit. Annel.*; the eyes on each side are very close together, almost touching. The bristles are exactly as described by Langerhans, the bulge just under the point of the stalk of the bristles being more pronounced than is shown in his drawing.

All the appendages are more or less speckled with opaque white spots.

TRYPANOSYLLIS ZEBRA, Grube. *McIntosh, Mon. Brit. Annel.*, vol. ii., p. 169.

This beautiful Syllid can be at once distinguished by the great proportionate breadth of the body and the markings, from which it derives its specific name.

It is fairly numerous, most of the specimens being obtained from Laminaria roots from the rocks between Babbicombe and Oddicombe beaches. No simple bristles were detected in the posterior region. It appears probable that these simple bristles in the Syllids generally only appear at certain periods, like the swimming pairs. Only one individual had a bud attached, but one free stolon was found. The number of spines varies from two to four. There are three different kinds of spines: one variety is pointed; another quite blunt at the point, looking as if it had been cut across at right angles to its length; the third variety is bent at right angles to its length at the point, forming a short hook. The segments are very short in proportion to their breadth, so that the large dorsal cirri almost touch each other.

TRYPANOSYLLIS CŒLIACA, Clpd. *de St. Joseph, Ann. des. Sci. Nat. Zool.*, 1886, p. 184.

This species, which has not been before recorded from this side of the Channel, is easily distinguished from the much larger T. zebra by the short tentacles, tentacular, and dorsal cirri. They have only six to ten articulations, and are all very nearly of the same length.

In life the cirri are of a most beautiful golden colour; the anterior eyes are situated on the ventral side of the head.

In most of the feet there is only one strong pointed spine, in others two. The proventriculus is very little longer than it is broad. Four or five specimens only were found; all from Oddicombe rocks.

EURYSYLLIS PARADOXA, Clpd. *de St. Joseph, Ann. Sc. Nat. Zool.*, 1886, p. 191.

Eurysyllis is easily distinguished from other Syllids by its spherical cirri; but the absence of comparatively long cirri, the sluggishness of its movements, and the fact that it is usually covered with mud, probably account for the fact that it has not before been recorded as British; de St. Joseph does not appear to have found it on the shore, but says it was common in the dredges. The Torquay specimens agreed with his description.

Examples were obtained from Oddicombe, Corbyn's Head, and Livermead, but none had buds.

AUTOLYTUS EHBIENSIS, de St. Joseph. *Ann. Sc. Nat.*, 1886, p. 228.

This is a very interesting addition to the British Fauna, on account of the excellent example it affords of the production of buds; de St. Joseph says he never found it without a bud, and I have only found two or three out of fifty or sixty examples without one.

Chains of five or six buds are common. In February, 1907, this species was found in great abundance on the Fucus, growing on the little breakwater at Babbacombe. The Fucus was covered with *Sertularia pumila*.

Two or three examples of the variety mentioned by de St. Joseph, with only twenty teeth in the proboscis, were also observed.

AUTOLYTUS PICTUS, Ehlers. *McIntosh, Mon. Brit. Annel.*, vol. ii., p. 211.

Rather common; the colour is similar to that of Pl. XLI., fig. 8, *Mon. Brit. Annel.;* but the tentacles are usually yellow instead of a madder-brown colour.

AUTOLYTUS MACROPHTHALMA, Marenzeller. *de St. Joseph, Ann. Sc. Nat. Zool.*, 1886, p. 226.

Two examples from Babbicombe. The teeth of the proboscis agreed

exactly with the figure given by Marenzeller. *Zur Kenntniss der Adriatischen Anneliden*, 1875.

AUTOLYTUS LONGIFERIENS, de St. Joseph. *Ann. des Sci. Nat. Zool.*, 1886, p. 217.

Five or six of this species, so remarkable for the great length (2 mm.) of the proboscis, were found. Two red eye-spots, not mentioned by St. Joseph, are situated rather a long way in front of the anterior pair of large eyes. In the Torquay examples there are only two small teeth between the large ones, instead of three, as is the case with those from Dinard.

AUTOLYTIDES INERMIS, de St. Joseph. *Ann. des. Sci. Nat. Zool.*, 1886, p. 237.

One specimen was found. The proboscis was of full length, and there appears no reason to think that the absence of teeth is due to an accident.

KEY TO THE GENERA OF THE SYLLIDÆ FOUND ON THE FRENCH AND ENGLISH COASTS OF THE CHANNEL, ACCORDING TO THE CLASSIFICATION OF MALAQUIN (*Recherches sur les Syllidiens*).

VENTRAL CIRRUS PRESENT.

Palps united throughout.	One pair of tentacular cirri.	Tentacles and cirri very small, cylindrical . . .	*Exogone*, Œrsted.
		Tentacles and cirri swollen at the base and pointed . .	*Sphærosyllis*, Clpd.
	Two pairs of tentacular cirri.	Tentacles and cirri long, wide at base, tapering to a point .	*Grubea*, Quatrf.
Palps united at the base only. Tentacles and cirri not formed of distinct joints.	Proboscis straight.	Proboscis without any teeth	*Syllides*, Œrsted.
		Proboscis armed with one tooth in the anterior part . .	*Pionosyllis*, Malmgren (Langh. *emend.*)
		Proboscis armed with one large tooth and an incomplete crown of small teeth	*Eusyllis*, Malmgren.
		Proboscis armed with teeth pointing backwards . . .	*Odontosyllis*, Clpd.
	Proboscis much curved.	Proboscis armed with a crown of small teeth . . .	*Amblyosyllis*, Grube.
Palps free throughout their length.	Proboscis armed with one large tooth.	Tooth situated in anterior part of proboscis . . .	*Syllis*, Savigny.
	Proboscis armed with one large tooth and a crown of small teeth.	Cirri of several articulations	*Trypanosyllis*, Clpd.
		Cirri spherical of one articulation	*Eurysyllis*, Ehlers.

VENTRAL CIRRUS ABSENT.

Palps little developed, united.	Dorsal cirri cylindrical or threadlike.	Proboscis armed with a crown of teeth	*Autolytus*, Grube.
		Proboscis without teeth	*Autolytides*, Malaquin.
	Dorsal cirrus leaf-like.	Proboscis very long (4 mm.)	*Myrianida*, Milne Edwards.

NOTE.—*Syllis cornuta* is joined at the base of the palps according to McIntosh, and *Autolytus* (*Sylline*) *rubropunctatus* has a ventral cirrus.

KEY TO THE SPECIES OF SYLLIDS FOUND ON THE FRENCH AND ENGLISH COASTS OF THE CHANNEL.

EXOGONE.			No dorsal cirri on 2nd bristle-bearing segment	*gemmifera*, Pagenstecher = *Pædophylax claviger*, Clpd.
SPHÆROSYLLIS.			4 eyes. Proventriculus with 12 rows of points. Anal cirri swollen at base	*hystrix*, Clpd.
			6 eyes. Proventriculus with 17 rows of points. Anal cirri not swollen at base	**erinaceus*, Clpd.
GRUBEA.			Dorsal cirri tapering to a sharp point	*clavata*, Clpd.
			Dorsal cirri almost cylindrical, widest in the middle with a blunt point	**pusilla*, Dajardin.
SYLLIDES.			Dorsal cirri long, yellow	*longocirrata*, Œrst.
PIONOSYLLIS.			Dorsal cirri of anterior segments very long (2 mm.)	*divaricata*, Keferstein = *longocirrata*, de St. Joseph.
			First pair of ventral cirri leaf-like. Dorsal cirri not very long	*lamelligera*, de St. Joseph.
EUSYLLIS.	Two large glandular tubes, one on each side of proboscis.		First pair of ventral cirri leaf-like, different in shape to other ventral cirri	*lamelligera*, Mar. et Bob.
			First pair of ventral cirri not different to others	*intermedia*, de St. Joseph.
	No glandular tubes.	Terminal pieces of bristles not differing greatly in length and breadth.	Dorsal cirri tapering towards apex	*tubifex*, Gosse.
			Dorsal cirri cylindrical	*Blomstrandi*, Mgr.
		Terminal pieces differing.	One kind short and stout, the other long and narrow	**monilicornis*, Mgr.
ODONTOSYLLIS.	Teeth of proboscis few and comparatively large.		Terminal pieces long and narrow. Length about nine times the breadth	*gibba*, Clpd.
		Terminal pieces short and broad. Length three times breadth.	Terminal pieces with a simple hook	*ctenostomata*, Clpd.
			Terminal pieces with a second tooth	*fulgurans*, Clpd.
	Teeth, numerous and small.		Terminal pieces bidentate	**polyodonta*, de St. Joseph.
AMBLYOSYLLIS.			13 pairs of feet. Appendages very long	*lineata*, Grube.

* Not yet recorded from British area.

KEY TO SPECIES—*continued.*

SYLLIS.

Simple bristles only present = sub-genus *Haflosyllus*, Langerhaus				*spongicola*, Grube = *hamata*, Clpd.
Compound bristles present in anterior and posterior regions. Simple bristles only in median = genus *Syllis sensu strictu*, Langerhans				*gracilis*, Grube.
Compound bristles present in all the feet.	Terminal pieces of all the bristles distinctly bidentate = genus *Pionosyllis*, McIntosh.		Dorsal cirri with more than 25 articulations. One or more simple bristles with bidentate apex in posterior portion of the body	*prolifera*, Krohn.
			None of the dorsal cirri with more than 25 articulations. A simple bristle not bifid at the apex present in posterior portion of body	*hyalina*, Grube
	Terminal pieces of some at least of the bristles a simple hook, at the most with a minute secondary tooth.	Bristles differing distinctly in the length and breadth of the terminal pieces or in the size of the stalks = sub-genus *Ehlersia*, Langerhans.	Terminal pieces of anterior and posterior regions long and narrow, with a minute secondary tooth, of median region short and broad with a simple hook	*alternosetosa*, de St. Joseph.
			Long and short terminal pieces mixed in all the feet	*cornuta*, H. Rathke.
			On some of the feet one or two compound bristles with a simple hook a little larger than the other, and a stalk twice as thick as the others	*æsthetica*, de St. Joseph = *Cunninghami*, McIntosh?
		Terminal pieces differing very little in size = sub-genus *Typosyllis*, Langerhans.	Tentacles and cirri with opaque white spots. Large and small cirri alternating	*Krohnii*, Ehlers.
			Dorsal cirri equal, no opaque white spots. — Dorsal cirri with 24 or more articulations. Length $1\frac{1}{2}$ inches	*Buskii*, McIntosh.
			Dorsal cirri equal, no opaque white spots. — Dorsal cirri with 10 to 12 articulations. Two lateral bars and a central bar of greyish brown on each segment	*armillaris*, Müller.
			Dorsal cirri equal, no opaque white spots. — Dorsal cirri with 9 articulations very stout	*brevicirrata*, McIntosh.
			Dorsal cirri equal, no opaque white spots. — Dorsal cirri crenate rather than moniliform. Two spines with distinctly curved tips.	*cucullata*, McIntosh.

KEY TO SPECIES—*continued.*

TRYPANOSYLLIS.	Dorsal cirri, alternating long and short, with about 40 and 20 articulations respectively		*zebra*, Grube.
	Tentacles and cirri, all nearly the same length, with 9 to 11 articulations		*cœliaca*, Clpd.
EURYSYLLIS.	Buccal segment distinctly visible from dorsal size.		*paradoxa*, Clpd.
AUTOLYTIDES.	Proboscis without teeth		*inermis*, de St. Joseph.
AUTOLYTUS.	Armature of proboscis 10 equal teeth of moderate size.	Dorsal cirri comparatively short. A simple bristle with a bent tip in each foot	*prolifer*, O. F. Müller.
	10 very large teeth, ·1 mm. long.	Proboscis, 2 mm. broad, 1 mm. long, almost straight	**megadon*, de St. Joseph.
	16 or 20 teeth not quite equal.	Appendages of head and first three segments massive. Eyes very large	*macrophthalma*, Marenz.
	16 small teeth equal in size.	Median tentacle and first pair of dorsal cirri very massive and opaque	**lugens*, de St. Joseph.
	24 unequal teeth.	Two transverse rows of glands on each segment	**punctatus*, de St. Joseph.
	24 equal teeth.	An orange coloured mark on each side of the back in front	**Edwardsi*, de St. Joseph.
	30 small equal teeth with short spurs at the base of the crown.	Colour dull grey	*ehbiensis*, de St. Joseph.
	30 or 34 equal teeth.	Four red or orange spots on each segment	*rubro-punctatus*, Grube = *ornatus*, Mar. et Bob.
	20 teeth, 10 large and 10 small.	Front part of the body marked with a regular pattern of brown spots	*pictus.*
	10 large teeth separated by 2 or 3 small ones.	Pharynx very long (18 to 20 mm.)	*longiferiens*, de St. Joseph.
	Number of teeth not known.	Dorsal cirri irregularly alternating long and short, the long about three times as long as the short	**paradoxus*, de St. Joseph.
MYRIANIDA.	Red spots on the back of segments		*pinnigera*, Montagu = *maculata*, Clpd.

* Not yet found in British area.

Notes on some Sagartiidæ and Zoanthidæ from Plymouth.

By

Chas. L. Walton.

Sagartia luciæ, Verrill.

THIS small species was described by Verrill in 1898, and first observed by Miss Verrill in 1892 near New Haven, U.S.A.

In 1902 Parker noted a number of new localities, and remarked upon its rapidly extending range on the American coast.

It has been known at Plymouth for a considerable period, being first observed in the Millbay Docks in 1896, and was identified by Mrs. Davenport in October, 1902. It was then to be found in the Cattewater, and I have lately observed it abundantly near high-water mark, under and upon stones in Rum Bay, and on Drake's Island in the Sound. It is thus extending its range here also in a quiet way.

It is certainly remarkable that this species should make its appearance on the American coast about 1892 and in Plymouth Docks in 1896. It is of course possible that it existed in both localities for some time previously, but it could hardly escape notice for long in a locality so constantly examined as Plymouth. As observed by Davenport (1903): "When the water becomes foul, or from other causes, it may voluntarily detach itself and float about the aquarium or hang upside down from the surface film." This I have also observed. Since it frequents docks, piers, and other situations, and near high-water mark, it is liable to become attached to the bottoms of ships, even floating to them in the still water usual in such places, and being very hardy, would survive a voyage, and again change its environment at the next port of call. It is significant that it was first noted at Plymouth in the Docks, and next in the Cattewater.

It is thus possible that it is not native to either the eastern coast of America or to South Devon, but was introduced into both areas about the same time.

In the Millbay Docks it lives upon the agglomerated masses of *Ascidiella aspersa*, which grow on the piles, valves of *Mytilus*, and upon one another, together with various *Polyzoa*, *Obelia longissima*, *Sycon coronata*, and colonies of *Botryllus*.

Height of column usually 5 or 6 mm., but I have seen adults when elongated as much as 10 mm. in height.

Column smooth, dull green, striped with orange-yellow.

Disk varies from semi-transparent greenish brown to dark green, with varying short lines or spots of greenish yellow at the base of the tentacles, and frequently one white radius.

Mouth generally raised on a cone.

Tentacles in multiples of twelve, 24, 36, 48, and 60 being observed in various individuals. Dull, semi-transparent, greenish in colour, or tinged with yellow or pink, sometimes a faint white ring near the tip.

Many of the conditions mentioned by G. C. Davenport, in "Variation in the stripes of *S. luciæ*," are observable here.

The anemone was in active subdivision on Drake's Island in early December, 1907, specimens being found with 4, 6, and 8 stripes more frequently than those with the normal 12.

Two large individuals, found on the same stone in Rum Bay, had the unusual number of 34 stripes, arranged in 17 pairs. One of these subsequently divided, and each of the resulting individuals had 17 stripes ($8\frac{1}{2}$ pairs).

Several small ones from Millbay were entirely without stripes.

I have observed one of these anemones seize and retain an amphipod of the same length as its own tentacles.

Sagartia coccinea, Gosse.

This species was named *coccinea* by Gosse, believing it to be identical with *Actinia coccinea*, Müller, Zool. Danica, 1776. Carlgren (1893) has shown, however, that the species really described by Müller was the *Stomphia churchiæ* of Gosse, which must hence be *Stomphia coccinea* (Müller), and the present species *Sagartia coccinea* Gosse.

It is to be found in abundance in the Cattewater, its presence there being in all probability due to trawl refuse, the majority being attached to the ascidian *Polycarpa pomaria*, and associated with other animals from the trawling grounds.

It however readily attaches itself to wood, leather, dead leaves, fucoids, and any other available material.

This species does not appear to be at all common, or at all events is seldom observed.

Base very irregular, generally lobed and twisted in a most peculiar manner. Fragments are constantly being split off, and speedily develop into fresh individuals.

Column very changeable in form. Surface finely corrugated, orange-buff with numerous yellowish white longitudinal lines, 12 of which are usually more prominent than the rest, paler about the base, and darker at the summit.

Disk as described by Gosse; the white radial lines and rich orange area about the tentacle bases.

Tentacles generally short and stout, but capable of considerable elongation. In many young specimens, 16 in number, 80 to 90 in the largest examined, they are colourless, with three broad white rings and marks at the base, as described by Gosse. Large specimens measured 12 mm. in diameter at the base. Height of column, 7–8 mm. Acontia emitted reluctantly and from the upper part of the column and the mouth; they are long and white. This species was seldom firmly attached, and could be removed from the ascidians, etc., with ease.

The following varieties were observed: (*a*) Some of the tentacles with two interrupted dark lines down their inner faces, somewhat as in *S. viduata*, but more to the front of the tentacles, not continuous, and never present on all the tentacles; (*b*) found upon water-logged wood, etc. Column perfectly transparent, the mesenteries showing as narrow white lines, the œsophageal region showing as an orange-red patch. The column of this form, tall and pillar-like, as in Gosse's figure, and the base less lobed. Height about 10 mm.

Disk transparent, pinkish-white, white lines as usual; the orange area reduced to thin light red lines around the bases of the tentacles. Mouth orange. Tentacles with indistinct white rings. Reproduction by longitudinal fission would appear to take place in this species. One quite small one was noted, divided into two as far down as the centre of the column. Carlgren remarks in 1896: *Studien uber Nordische Actinien*, p. 96, *Sagartia undata, var. undata β*, "Möglicherweise ist diese Form identisch mit Gosse's (nicht Müller's) *S. coccinea*."

Lack of the necessary material and literature prevent an attempt to elucidate the relationship of the form with regard to the above, to *S. viduata*, to *S. herdmani*, and to *S.* (*Actinia*) *lacerata*, and I therefore retain Gosse's name.

Sagartia sphyrodeta, Gosse.

Specimens were examined from the Asia Shoal, Reny Rocks, and other localities. They all belonged to the *var. candida* of Gosse. His variety *Xanthopis* I have not yet met with here, though it occurs on the north Cornish coast.

Some of the specimens had a pale bluish or glaucous tinge on the column, and I have seen a variety near St. Ives in which this colour predominated on the column in darker and lighter bands. The tentacles, according to Gosse, number 48 (8 + 8 + 16 + 16). Fischer (1874) gives 8 + 8 + 16 + 32 + 64. The usual number at Plymouth is 64 (8 + 8 + 16 + 32), but a few have about 100. Their form is changeable. "They are usually spread horizontally, and have their tips bent frequently downwards" (Gosse, p. 73).

Sometimes they are much inflated, and curve in all directions, and are often very active. Both these conditions are most frequent in those dredged in the deeper parts of the Sound, and in such also the column is more pellucid and the tentacles more extensile than in the littoral form. I have observed one exhibit extraordinary activity, bending all the tentacle tips, and then straightening them again all together and at the same time.

The lines encircling the tentacle bases, usually dark brown, sometimes light purple, or only the inner cycles so encircled. They are frequently irregular, spreading out as a dark coloured area, or forming dark patches at the sides of the tenacles. Acontia freely emitted. Transverse sections showed the ectoderm to be well developed (especially in the oral disk), and the mesoglœa, though not markedly developed in the body wall, mesenteries, or tentacles, is also thicker in the oral disk, and the sphincter is strong, and shows numerous small cavities. The longitudinal muscle of the mesenteries well developed, the fibres dendritic.

Paraphellia expansa, Haddon.

This species is not uncommon on the Rame-Eddystone grounds, but I have only been able to examine one living specimen from that area, which had been in captivity for some time. When completely contracted, 20 mm. in diameter, and much flattened, the base spread out, sometimes smooth, and at others crenulated, the centre slightly elevated and much wrinkled. The form is very changeable, the flattened base being partly or wholly retracted, the column elevated, and the anemone then assumes the turban shape figured by Haddon, but this is rare.

This specimen does not progress by the usual creeping method, but by drawing in the flat base, inflating one side of the column, and falling over in that direction, thus turning upside down and resting on the partly expanded oral disk and tentacles. One side of the pedal disk is next inflated, and the anemone rights itself again, and so on. The body wall was covered by a thin horn-coloured coating of hardened mucous, in which a good many sand grains were embedded. Remains of an older and thicker coating could be made out. The thin coat was easily removed, and the animal expanded more freely in consequence. The whole base and column were then seen to be "translucent buff," but with no sign of the "pinkish or flesh colour" on the scapus, as in Haddon's Irish specimen. Tentacles $6+6+12+24+48=96$, one cycle more than in Haddon's examples. They were coloured as given in his plate and description, but varied in intensity, some being largely white, others with a wash of pale chrome, especially about the base. The brown terminal spot very weak or absent. The lateral spots of brown, in two or three pairs, well marked or almost absent.

Disk pale brown, with 12 somewhat darker areas radiating from the primary tentacles to the mouth, these areas bordered by double yellowish lines (single in Haddon's specimens).

From the bases of the secondary tentacles, and on a paler ground, lines of white dots run towards the mouth.

Mouth raised in a cone, lips pale, throat same, longitudinally ribbed, and banded with dark brown. Acontia freely emitted from the mouth.

I recently obtained seven specimens adhering to stones at extreme low water at Zennor, near St. Ives, Cornwall, and as this is a new habitat and locality for this species, a short description may be of interest. An abundant growth of *Laminaria* and several layers of stones having been removed, these anemones were found adhering firmly to the sides and lower faces of the stones, together with *Corynactis viridis* and *Caryophyllia*, etc. When contracted they resembled Haddon's figure (*Trans. R., Dublin Soc.*, Vol. iv., Pl. XXXII, Fig. 2), and were invested in a thick brown, wrinkled, bark-like coating, and the scapus proved to be pale flesh colour on its removal. In no case, while in my possession, was a flat or crenulate base to be seen. This is probably limited to specimens living on a sandy bottom. Disk tawny brown. The arrangement of lines and dots was more complicated than in either the Irish or Plymouth specimens, but on the whole was very similar. The tentacles 96 in the larger specimens; in these also there were slight variations of arrangement of tint and markings.

Soon after capture several ejected shells of *Homalogyra atornus*, which is abundant on the rocks there.

P. expansa thus appears to have a fairly wide range on the western coast, and to be variable in colour and form.

Epizoanthus couchii, Johnston.

Zoanthus couchii, Johnston, 1838; Gosse, 1860.
Epizoanthus couchii, Haddon and Shackelton, 1891.

A colony dredged on December 6th, 1907, from Duke Rock, Plymouth Sound, consisted of fifteen polyps of various sizes attached to a stone. Cœnenchyme thin and irregular. The larger polyps 15 mm. in length, gradually widening toward the summit. Encrusted with sand. The lower $\frac{2}{3}$ of the column was weak, less encrusted than the summit, and incapable of supporting the upper portion. The upper $\frac{1}{3}$ contractile, and this gives these polyps a "knobbed" appearance. If irritated, the whole column stiffened somewhat, but usually lay bent over, the summit resting on the stone. The half-grown polyps all showed more or less narrowing about the base, but those of 2–4 mm. are the same thickness throughout.

Fresh polyps appear to arise as small mound-like swellings in the cœnenchyme. Small isolated individuals were also to be observed on the same stone.

Disk concave, olive with white lines. Mouth elevated. Lips opaque white. Tentacles 24 to 28, in two cycles, fairly long and transparent. Tips rather blunt and white. Marginal teeth, 12 to 16. In some cases well developed; in others less so.

Lives well in confinement; very timid, contracting at the least vibration.

Epizoanthus (?) rubicornis (Holdsworth).

Zoanthus rubicornis, Holdsworth, 1861.
Epizoanthus (?) rubicornis, Haddon and Shackleton, 1891.

Haddon and Shackleton (1891), p. 653, say: "This species has apparently not been met with since its discovery, and we are unable to do more than recast Holdsworth's description. We have no doubt that this species is an Epizoanthus."

I have examined two preserved colonies, marked "Five miles southwest of Rame Head, September, 1902."

Colonies unattached. From their conformation they would appear to have lain free on a sandy bottom, the polyps all being bent slightly upward.

Colony (a) consists of two large primary polyps growing from a centre, away from one another, and in the same plane; two secondary polyps arising in a similar manner at right angles to the first pair, and two smaller tertiary polyps arising from the bases of the primary pair.

Colony (b) is formed upon the same plan, but is more irregular in growth, and consists of seven polyps.

Greatest length of colony (a) 40 mm., largest polyp 20 mm. in length, and 5 mm. in width at the summit, and 3 mm. at the base.

Breadth of colony 22 mm., the polyps 10 mm. long. Tertiary polyps 5 mm. Measurements of (b) very similar.

In both colonies there were swellings at the base of the secondary polyps, indicating further branching.

Body wall strongly incrusted with sand, a few folds on or below the summit of the larger polyps.

Capitular ridges, 15 or 16, not strongly developed. Spaces between the ridges unincrusted.

Disk not visible. Tentacles partly retracted, stout, and white, 26 visible in one and 24 in another. Mr. A. J. Smith informs me that they were of an orange-red when fresh.

These specimens are evidently identical with that described by Holdsworth, and which was also obtained in the neighbourhood of Plymouth.

An anatomical examination was not attempted, as owing to the amount of incrusting sand, and the fact that the specimens had been five years in formalin, the result would be certain failure, to judge by an experience with *E. incrustatus*, besides mutilating the colonies. Fresh and less incrusted examples must be awaited and hoped for.

In the meanwhile I agree with previous writers as to the close affinity of this form with *E. couchii*.

Parazoanthus dixoni, Haddon and Shackleton.

One colony, preserved in alcohol. The label reads: "Millbay Channel, December 1st, 1902."

This colony, which consisted of over 50 polyps, had evidently been torn off a rock by the dredge, as fragments of stone and *Balanus* were found still adhering to the cœnenchyme.

Greatest length of colony 35 mm., breadth 27 mm. Height of largest polyps 10 mm., diameter 4 mm. Cœnenchyme soft, spongy, and abundant. Polyps rather crowded. Body wall slightly wrinkled, owing to the contraction of the polyps.

The whole colony bears a strong resemblance to that figured by Haddon and Shackleton, *Revis. Brit. Actiniæ*, Pt. II, Pl. LVIII, Fig. 37.

Polyps stout, contracting somewhat toward the summit, where they again enlarge. Margin rounded, with 16 to 18 well-developed ridges. Disk and mouth not visible.

Tentacles difficult to enumerate, almost all being retracted. Thirty were visible in one large polyp, fairly stout, and dull white in colour. Colony sand colour.

A transverse section shows the ectoderm and nematocysts, encircling sinus and canals, endoderm, etc., to be as described by Haddon and Shackleton. The incrustations, consisting of sand grains, spicules, etc., were, however, more numerous than in their specimens.

The specimens described by the above-mentioned authors were obtained off the coast of Kerry, Ireland, in 70–80 fathoms. The Millbay pit, from which the present colony was probably obtained, has a depth of from 12 to 17 fathoms.

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Actiniæ collected by the s.s. "Huxley" in the North Sea during the summer of 1907.

By

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The following species were obtained:—

Bolocera tuediæ (Johnston).
Bolocera longicornis, Carlgren.
Tealia coriacea (Cuvier).
Rhodactinia crassicornis (O. F. Müller).
Stomphia coccinea (O. F. Müller).
Sagartia undata (O. F. Müller).
S. miniata (Gosse).
S. viduata (O. F. Müller).
S. pallida (Holdsworth).
Sagartia sp.
Chondractinia digitata (O. F. Müller).
Metridium dianthus (Ellis).
Epizoanthus incrustatus (Dub. and Kor.).
Cerianthus lloydii, Gosse.

BOLOCERA TUEDIÆ (Johnst.).

Voyage XCIII. Station 37. Northumberland ground. 40 fathoms. 1 specimen.

Voyage XCIII. Station 56. Lat. 55° 31′ N. Long. 0° 53′ W. 55 fathoms. 2 specimens.

The specimen from 93–37 was young and damaged. Expanse of disk and tentacles in a contracted condition, 30 mm.

Column much contracted and wrinkled, and of a dirty white; outer cycle of tentacles of the same colour, the inner cycles rose-pink. Disk dull uniform pinkish white, mouth the same and protruding, two pink œsophageal grooves.

Many of the tentacles were missing, especially from the inner cycles; these were three times the length of the outer. The animal, although injured, was still alive when first captured, and the tentacles underwent constant inflation and contraction; during contraction the sulcations showed strongly.

The two examples from Station 56 were large, and in size and colour agreed with the description in Gosse's *British Sea Anemones and Corals*, p. 186–7. Gosse there writes that the column is "studded somewhat sparsely with minute rounded warts, scarcely apparent when the animal is extended," etc., and also quotes Cocks to this effect; Carlgren, in 1891, discusses the matter, and concludes that the warts described were due to the contraction of the body wall. In the two examples now under consideration, no warts were to be found when living and expanded, but when preserved and contracted the body wall is thrown into innumerable wart-like folds, which any one who had not seen the animal in a living state might easily take to be genuine warts. The figure on Plate V (of Gosse) certainly does not show a fully expanded specimen, as the tentacles are contracted (for although incapable of retraction they can be considerably contracted). The number of tentacles present in the more perfect specimen amounted to 127, but so many had been thrown off that anything like an accurate enumeration was impossible.

The internal preservation was bad, but 77 pairs of mesenteries were recognisable.

Measurements fo a preserved specimen:—Breadth of pedal disk, 40 mm. Breadth of oral disk, 50 mm. Height of column, 55 mm. Length of tentacles of the inner cycle, 40 mm., of outer cycle, 15–20 mm. In colour, one approximated very nearly with Gosse's description, but paler; the other very pale, merely tinged with pink and light brown on the inner face of the tentacles, etc. The stomach protruded considerably.

BOLOCERA LONGICORNIS, Carlgren.

Voyage XC. Station 7. Great Fisher Bank. Lat. 56° 59′ N. Long. 2° 53′ E. 38 fathoms. 2 specimens.

Voyage XC. Station 10. The Gut. Lat. 56° 40′ N. Long. 1° 32′ E. 50 fathoms. Abundant, and at other stations in this area.

Voyage XCIII. Station 99. Lat. 55° 48′ N. Long. 0° 49′ E. 45 fathoms. 1 specimen.

Voyage XCIII. Station 101. Lat. 55° 48′ N. Long. 1° 4′ E. 40 fathoms. 1 specimen.

Voyage XCIII. Station 106. Lat. 55° 41′ N. Long. 2° 13′ E. 43 fathoms. 7 specimens.

Voyage XCVI. Station 1. Lat. 56° 0′ N. Long. 3° 23′ E. 38 fathoms. 4 specimens.

Voyage XCVI. Station 5. Very near last. 27½ fathoms. 1 specimen.

This species was first described by Carlgren, in 1891, from specimens obtained on the west coast of Sweden, from depths of from 40–80 fathoms. In 1893 he gave a much more detailed account, and mentions the Gullmars-fjord, "other localities on the Swedish west coast," and the Skagerrak as its distribution.

Only a few of those obtained by the S.S. *Huxley* were in a perfect condition, the best being those taken in the Agassiz trawl during short hauls; those from beam hauls of several hours' duration being frequently almost destitute of tentacles, which would be found adhering to the mesh in all parts of the trawl.

None of the specimens attained the dimensions of those described by Carlgren, and measurements of fully expanded specimens were not easy owing to the generally great and usually unequal inflation of the body wall. The height of the column varying from 50 to 100 mm. Breadth of oral disk usually equal to the height. Length of inner cycle tentacles up to 80 mm, the outer 25–30 mm.

Pedal disk thin and not well demarcated. None were attached, but were free in the trawl, and only adhered in a slight degree to any vessel in which they were kept, and as they showed no sign of having been torn from any object it is probable that they lie loosely upon the bottom (sandy).

Column smooth and polished and thin, finely wrinkled when contracted. Tentacles 160, in six cycles in the larger specimens, stout, tapering to the tip, strongly sulcated, fairly contractile, constricted at the base, and very readily thrown off. Disk smooth, two large œsophageal grooves, stomach freely protruded and grooved.

Some few were of the colours described by Carlgren, "flesh colour all over, tentacles often brown-red on the inner side, gonidial-tubercles and primary mesenteries weak carmine." But the majority had the column chestnut or dull orange (the mesenteries showing as faint white lines during distention)

Tentacles maroon or, rarely, chestnut, the inner faces much darker than the outer, and the inner cycles darker than the outer. Disk a warm flesh tint, or light orange-brown, with numerous irregular radial lines of dark brown or maroon, of varying widths, but widest and darkest about the base of the tentacles. Œsophageal grooves flesh colour. Throat and stomach brownish pink. The colours persist well

in preserved specimens. *B. longicornis* is not easy to keep alive, and soon after capture usually protrudes the stomach walls to an enormous extent, collapses to an abject flatness and dies.

RHODACTINIA CRASSICORNIS (O. F. Müller).

In 1902, O. Carlgren, in his paper on the Actiniæ of the *Olga* expedition considered that the name *Urticina* (*Tealia*) *crassicornis* really covered three species belonging to two genera, i.e., *Rhodactinia crassicornis* (O. F. Müll.), *Tealia coriacea* (Cuv.), and *Tealia lofotensis* (Dann.).

Unfortunately I did not see this paper until after the voyages, and regarded all the forms obtained as varieties of *Urticina crassicornis.* merely making notes on colour and external characters at the time of capture. In these notes I however distinguished three forms: (*a*) *U, crassicornis*, the normal form of the littoral area; (*b*) the large deep-water form, the *Tealia tuberculata* of Cocks and Cunningham, and (*c*) a form with small warts, occurring on the Great Fisher Bank. A subsequent anatomical examination of such specimens as were preserved shows this last to be *R. crassicornis* and the other two to be forms of *T. coriacea.* It is thus almost impossible to assign all the numerous records to their real species, only those cases where my notes actually notice the size of the warts and the preserved specimens can be safely noticed.

R. crassicornis occurred at several stations during Voyage XC about the region of the Great Fisher Bank, together with *B. longicornis* and *Chondractinia digitata.*

Almost all the specimens were large, having an expanse of from 12 to 14 cm. They were attached to valves of *Cyprina islandica* and *Modiola*, both dead and living, and *Fusus antiquus*, either living, empty, or tenanted by *Eupagurus bernhardus*, and once upon the shell of a living *F. turtonis.*

The small warts which beset the upper part of the column are arranged in irregular vertical rows, and during partial contraction the arrangement frequently appears annular. The colouration is very variable; the following were noted:—

(*a*) Much resembles Gosse's description and plate of *Bolocera eques.* The margin was frequently not retracted, even when the tentacles had been withdrawn. The disk, however, was never "pellucid," nor was the scarlet tentacular ring bounded by white, as described by Gosse.

When I first saw this I took it to be *B. eques.*

(*b*) Column dull orange, the summit white. Tentacles dull pink, the scarlet ring indistinct. Disk pale orange.

(*c*) Like the last, but the disk dull pink, and the mouth area vivid rose-red.

(*d*) Column as (*a*). Disk dull white, smudged with yellow. Tentacles a fine rose-red, inner faces darkest, scarlet ring not distinguishable, basal lines chestnut.

(*e*) Column as (*a*). Disk red. Tentacles with an indistinct white ring, no scarlet band.

(*f*) Column dull orange, summit red, the fosse blue. Disk cobalt blue, two red circles around the mouth. Tentacles dull orange-brown, red ring well defined, basal lines faint.

In others the column was blotched with scarlet.

In all cases the warts were white. The stomach frequently everted to a considerable extent.

The food of this species appeared to be varied, a full-sized *Spatangus purpureus* and larger shells of *Cardium* and *Psammobia* were ejected after capture, and considerable masses of *Tubularia*, though this may have been obtained in the trawl. Those kept alive swallowed *Dendronotus arborescens* with avidity, but refused *Tritonia hombergi*.

TEALIA CORIACEA (Cuvier).

The large deep-water form, described as *Actinia tuberculata* by Cocks and *Tealia tuberculata* by Cunningham, was obtained from various localities.

The colours are generally pale and the warts on the column large. The tentacles 160 in number; in several there was a bifurcation of one or more.

Usually attached to shells (dead). Near the coast, in shallow water, specimens resembling the ordinary shore form were obtained.

STOMPHIA COCCINEA (O. F. Müller).

Actinia coccinea, Müller, 1776.
Stomphia churchiæ, Gosse, 1859.
Stomphia coccinea, Carlgren, 1893 and 1902.

Voyage XCIII. Station 47. Off Seaham. 14 fathoms. 1 specimen.

Voyage XCIII. Station 65. Lat. 55° 35′ N. Long. 0° 50′ W. 45 fathoms. 6 specimens.

Voyage XCIII. Station 73. Lat. 55° 39′ N. Long. 1° 10′ W. 50 fathoms. 7 specimens.

Voyage XCIII. Station 75. Near the last. 50 fathoms. 11 specimens.

Voyage XCIII. Station 77. Off Holy Island. 32 fathoms. Common.
Voyage XCIII. Station 82. Off St. Abbs. 37 fathoms. 1 specimen.
Voyage XCIII. Station 83. Lat. 56° 7' N. Long. 1° 22' W. 42 fathoms. 1 specimen, and at a number of other stations in that area a few specimens, or common.
Voyage XCIV. Station 23. Lat. 53° 49' N. Long. 0° 15' E. 15 fathoms. 1 specimen.
Voyage XCVI. Station 20. Lat. 54° 11' N. Long. 1° 40' E. 22 fathoms. 1 specimen.

Adhering to stones and dead shells. Several from 93–77 were upon living shells of *Aporrhais pes-pelecani*, the dead shells used were usually *Modiola modiolus* and *Psammobia ferrœnsis*, etc. In confinement this species displays much restlessness, detach themselves and roll about the vessel or tank, re-attach and again loosen, and so on, also as Gosse observes (p. 222), " very protean in shape," and frequently assumes the shape shown in Gosse's figure (Pl. VIII).

Colours very variable; the column is always smooth, and has a satiny lustre, the crimson or yellowish white predominating according to the individual. Disk dull red or white, streaked with red; lips usually crimson; throat dull white or pink. In some specimens a circle of dull spots upon the inner third of the disk. Œsophageal grooves, two, red. The pedal disk is frequently flecked and streaked with red of considerable intensity; this is probably corellated with the habit of living for varying periods unattached, lying on the side on hard rocky ground such as it favours. The tentacles pellucid white, with one or two bright red rings, or only one ring near the tip; sometimes the rings are indistinct or a white ring below the red ones. Red lines frequently run down the sides of the tentacles on to the disk. In some also a white spot is present at the base of each tentacle of the two inner cycles, thus forming two alternate circles of white spots. In several, from XCIII. 90, the column and disk were very pale and almost transparent, but the tentacles and throat were red.

It was noticeable that when a series of stations was worked at intervals away from the coast (Northumberland), the colours of this species became more and more faint, until the column was so transparent that the mesenteries could be counted with ease.

SAGARTIA UNDATA (O. F. Müller).

Actinia undata, Müller, 1788. Zool. Danica.
Sagartia troglodytes, Gosse, P. H., 1860.
Cylista undata, Andres, 1883.
Sagartia undata, Carlgren, O., 1893.

Voyage XCV. Station 24. S. edge of Coal Pit. 13 fathoms. 1 specimen.

A small specimen attached to a stone among *Serpulæ* and *Balanus*, and only visible when elongated and expanded.

Column cylindrical pink, white longitudinal lines near the base, some sand attached. Disk pure satiny white. Mouth flat, throat buff. Tentacles 70–80, not very long, yellowish white, barred transversely, some with two ill-defined dark lines upon the front face, and a rather prominent B mark at the foot.

SAGARTIA VIDUATA (O. F. Müller).

Voyage LXXXIX. Station 22. Lat. 54° 28′. Long. 2° 36½′ E. 18 fathoms. 1 specimen.

Voyage XC. Station 2. Off Esbjerg. Lat. 55° 22⅝′ N. Long. 8° 10½′ E. 8 fathoms. Several specimens.

Voyage XCII. Station 10. Lat. 54° 0′ N. Long. 6° 46¾′ E. 16 fathoms. 6 or 7 specimens.

Voyage XCII. Station 28. Lat. 54° 51½′. Long. 6° 38′ E. 22 fathoms. Common.

Voyage XCII. Station 31. Lat. 54° 47⅞′. Long. 6° 30′ E. 21 fathoms. Abundant.

Voyage XCII. Station. 34. Lat. 54° 2′. Long. 6° 54′ E. 14 fathoms. Several.

Voyage XCII. Station 42. Lat 54° 23′. Long. 7° 47′ E. 12 fathoms. Fairly common.

Voyage XCIV. Station 54. Sole Pit. 47 fathoms. 2 specimens.

Voyage XCIV. Station 56. Sole Pit. 45 fathoms.

Voyage XCVI. Station 15. Lat. 54° 30′ N. Long. 3° 59′ E. 25 fathoms. Fairly common.

Voyage XCVI. Station 17. Lat. 54° 20′ N. Long. 1° 43′ E. 24 fathoms. 1 specimen.

Upon stones, valves of *Ostrea*, lumps of slag and one from 89–22 in a hollow on a lump of "Moorlog," also inside empty shells of *Buccinum*.

Colours, etc., as described by Gosse, Carlgren and others, those from more than 40 fathoms paler than usual.

SAGARTIA MINIATA (Gosse).

Voyage XCII. Station 28. Lat. 54° 51½′. Long. 6° 38′ E. 22 fathoms. 8–9 specimens.

Voyage XCIII. Station 27. Off Whitby. 25 fathoms.

Voyage XCIV. Station 54. The Sole Pit. 47 fathoms. 5 specimens, and at four other stations in the same area, common.

Voyage XCV. Station 7 Smith's Knoll, L. V. 26 fathoms. 5 specimens.
Voyage XCV. Station 20. Knoll Deep. 22 fathoms. 4 specimens.
Voyage XCV. Station 24. S. edge of the Coal Pit. 13 fathoms. Fairly common.
Voyage XCVI. Stations 15 and 16. Lat. 54° 30′ N. Long. 3° 59′ E. 25 fathoms. Very common.
Voyage XCVI. Station 17. Lat. 54° 20′ N. Long. 1° 43′ E. 24 fathoms. Fairly common.
Voyage XCVI. Station 18. Lat. 54° 20′ N., near Long. 1° 43′ E. 24 fathoms. One or two.

This species usually occurs in colonies upon living and dead *Ostrea*, frequently clustered about the base of a colony of *Alcyonium digitatum* (growing on the *Ostrea* also), their bases overlapping or overlapped by the edge of the colony of *A. digitatum*, and often with *S. viduata*.

The colour as a rule is very variable, particularly as regards the outer cycles of tentacles, the "core" of these, though generally scarlet, may be orange-red, faint orange, or without any difference in colour from the inner cycles. Disk also variable, each colony usually being fairly uniform as to the colour of the outer tentacles and the number of the "gonidial" radii, one colony of 7 (from 96–15) having one very broad white radius each, and the same occurred in a colony of *S. viduata* from the same station.

Those procured in the Coal Pit in from 42 to 47 fathoms, bottom black mud, were identical in colouring (and as bright in colour) as those abundant in rock pool at low tide at East Hartlepool.

SARGARTIA PALLIDA, var. **RUFA** (Holdsworth).

Voyage XCVI. Station 15. Lat. 54° 30′ N. Long. 3° 59′ E. 25 fathoms. 8 or 9 specimens.

This colony was attached to a valve of *Ostrea*, together with young *Metridium dianthus*, to which, when contracted, they bore a strong superficial resemblance, and where that species is abundant would be easily passed over as the young form of one of the colour varieties.

Size of largest specimens.—Expanded diameter, 20 mm. Height, 15 mm. Length of tentacles of inner cycles, 10 mm. Column smooth and of a uniform dull orange-brown. Base somewhat spreading. Disk dusky white, mouth and throat orange ribbed. Tentacles numerous, about 200 in 5 (?) cycles, a double white spot at the base, which is also encircled by bowed bluish black lines; these lines give the disk a dusky appearance, and show through the body wall when contracted as a broad blackish band. One very young specimen had the column orange in colour and only eight tentacles; another, somewhat larger,

24 tentacles. In the first of these the basal lines were not visible; in the one with 24 tentacles they were blue, and the tentacles had a faint white core.

Acontia were emitted from both mouth and column.

These larger specimens were much more robust and darker in colour than any I have seen on the English or Welsh coasts; in such the column is generally white or pale orange (as in the young form described above), and the basal lines blue or purple.

With the exception of this species (and the next to be described) the anatomy of most of the forms obtained by the *Huxley* is well known. An attempted investigation of this species ended in failure; the tissues were hard and brittle, due to preservation in too high a percentage of formalin. The external form and colour were excellently preserved however. It would be well when several specimens are obtained to preserve those intended for anatomical purposes in alcohol, and museum specimens in formalin.

SAGARTIA SP.

Voyage XCIV. Station 56. The Sole Pit. Lat. 53° 36′ N. Long. 1° 30′ E. 45 fathoms. 1 specimen.

Attached to a dead valve of *Ostrea.* Expanded diameter, 25 mm. base slightly exceeding the column, outline irregular and lobed. Column firm, much wrinkled during contraction, slightly so when expanded. The summit smooth, margin tentaculate; a few weak suckers on the upper parts of the column. Colour of column dull white, the mesenteries showing as white longitudinal lines, especially about the base.

Disk transparent white, the mesenteries showing as numerous white radial lines; mouth large and frequently gaping; lips lobed, yellowish; throat brownish buff.

Tentacles about 96 in number, thick and swollen at the base, tapering gradually to the tip, white (showing an irregular white core during contraction), with a faint lilac tinge, stronger upon the lower parts and most pronounced during contraction. During complete contraction the tentacles show through the column wall as a broad lilac or light purple area. Examination with a lens showed this colour to occur upon the tentacle in little streaks. Acontia sparingly emitted and only after severe irritation. Much flattened upon complete contraction. I am not aware of any species of the genus to which I can safely refer this form, but it appears to be nearly allied to *S. miniata*; further material may provide additional evidence and permit of the form being examined anatomically.

CHONDRACTINIA DIGITATA (O. F. Müller).

Occurred frequently in abundance at many stations in the region of the Great Fisher Bank and about Lat. 55° 31′ N., Long. 0° 53′ W.; 55° 48′ N., 0° 49′ E.; 55° 44′ N., 1° 40′ E., and many other stations in those areas in from 34 to 55 fathoms.

Generally attached to the shells of various species of *Fusus*, either living or inhabited by *Eupagurus bernhardus*. Those from the Great Fisher Bank showed great variability in the size of the warts and colour of the column, etc.; there might be but one row of prominent warts near the summit, or they might be scattered thickly over the greater part of the column, and the colour of the column varied from dirty white to dull orange, and the tentacles from dull pale lilac to light brown.

In a few there was a tendency to mammillation in the warts thus approaching *C. nodosa*, though none could be placed in that species. Carlgren mentions similar cases, but in a region where both forms were to be found. He found it difficult to determine to which species some individuals should be assigned.

METRIDIUM DIANTHUS (Ellis).

This species was found so constantly and abundantly throughout the entire area investigated, as to render an enumeration of localities unnecessary. All the colour varieties mentioned by Gosse, Carlgren, and others were represented, with the exception of the sulphur and lemon-yellow; this appears to be somewhat rare (it is abundant in places on the coast of N. Wales). The most frequent in the North Sea is a dirty white, especially in the deeper water. Carlgren (1893, p. 102) says "Die rein weisse Varietat" (var. *sidonea*, Gosse, 1860, p. 13) "habe ich nur in tiefem Wasser angetroffen." In shallower areas the red, pink, and pale orange are abundant; the dark brown and olive forms were only taken occasionally.

This species is to be found attached to stones, wood, *Algæ*, *Alcyonidium gelatinosum*, *Buccinum*, *Fusus* (in such it usually occupies the apical region), upon the surface of *Cancer pagurus*, etc., etc. I have seen a large female *Cancer* almost entirely covered by an enormous red anemone.

Pycnogonum littorale is frequently to be found clinging about the base of this species, and on several occasions I have observed it feeding upon this and other species. The proboscis is sunk deeply into the tissues, and the claws are hooked into the body wall. It requires a sharp pull to draw out the proboscis, and the tissues around the puncture were generally discoloured, showing the proboscis to have

remained inserted for some considerable time. *P. littorale* was observed feeding in a similar manner upon *Chondractinia digitata* in the region of the Great Fisher Bank, and *Sagartia miniata* from the Sole Pit, neither the tough body wall in one case nor the acontia in the other being sufficient protection. The coloured tissues of the anemone were often visible within the body and proboscis of the *Pycnogonum*, and that these attacks may prove fatal to young Actinians was observed in my aquaria in the spring of 1907 at Newquay, in Cornwall, a young *Sagartia* being speedily killed, and young *Bunodactis thallia* (Gosse) were much injured.

I have since seen it feeding upon *Actinia equine*, Linn., and young *M. dianthus* in the Plymouth aquaria.

EPIZOANTHUS INCRUSTATUS (Düb. and Kor.).

Voyage XCIII. Station 34. East of Shields. 38 fathoms. Common.
Voyage XCIII. Station 37. Northumberland ground. 40 fathoms. 5 specimens.
Voyage XCIII. Station 59. Lat. 55° 31′ N., 0° 36′ W. 47 fathoms. Common, and a number of other stations in that area in 40 to 57 fathoms.

The colonies varied greatly in size, number of polyps, etc. All were incrusting forms, forming carcinæcia by replacement of the shells of gastropod shells; the carcinæcia were inhabited by various species of *Eupagurus*. The smallest colony consisted of 4 polyps. The largest obtained measured 42 mm. in length, and the polyps varied from 12 mm. in height and 7 mm. in breadth to 6 mm. by 4 mm.

The number of polyps in a colony was usually 10, but as many as 30 were counted in one case, many of these being, of course, mere buds.

The incrustations were extremely dense, the ectoderm and mesoglœa being permeated with sand, and there was usually a considerable amount in the cœlenteron. Repeated attempts to observe the polyps expanded all failed, owing to the motion of the ship, the animals being very timid.

CERIANTHUS LLOYDII, Gosse.

Voyage XCIII. Station 36. East of Shields. 38 fathoms. 2 specimens.
Voyage XCIII. Station 39. Northumberland ground. 34 fathoms. 1 specimen.
Voyage XCIII. Station 70. Lat. 55° 39′ N. Long. 1° 10′ W. 50 fathoms. 1 specimen.

Of these only the last was in a sufficiently good condition to be of use, the others were badly injured by the trawl.

Length when living, 60 mm. In spirit, 27 mm.

Column cylindrical, tapering gradually posteriorly.

Body wall transversely wrinkled, the upper portion also grooved and ridged longitudinally, each ridge corresponding to one of the fully developed tentacles of the marginal cycle.

Tentacles of the marginal cycle about fifty in number, but difficult to determine, as many were quite small and evidently just developing. It was likewise impossible to enumerate the inner tentacles in a preserved condition as they were crowded together and broke in pieces if any attempt was made to separate them. The animal would not expand fully when alive.

When living the colouration agreed with the description given by Gosse. The column was uniform yellowish white, with a dark olive-green band at the summit, they area from which they arise white, and upon the base of the tentacles a series of maroon or purple patches. Marginal tentacles slender, not long; light yellowish brown, with indistinct bars of chestnut brown across the inner faces. The oral series very dark maroon.

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Nudibranchiata Collected in the North Sea by the s.s. "Huxley" during July and August, 1907.

By

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DURING July and August, 1907 (Voyages XCII, XCIII, XCIV, XCV, and XCVI), the s.s. *Huxley* worked a series of stations reaching from near Cromer to St. Abb's Head more or less parallel with the coast line, and also a series further to the north, and extending around the eastern borders of the Dogger Bank.

Many of the hauls were in and about "roughs," and, as might be expected, a considerable number of species of Nudibranchs were obtained, some of them of considerable interest. The specimens were examined in the living state as thoroughly as circumstances permitted, and as often as possible in their natural environment. Unfortunately in many cases this was impossible, as the animals had become either detached in the dredge or trawl, or were found adhering to the mesh of the nets, and were in consequence more or less injured.

All the specimens were killed with menthol, preserved in formalin, and subsequently re-examined in the Laboratory at Lowestoft.

The following species were obtained :—

Aeolidiidæ.

1. *Aeolidia papillosa* (Linn.).
2. *Aeolidiella alderi* (Cocks).
3. *Aeolidiella glauca* (A. & H.).
4. *Cuthona nana* (A. & H.).
5. *Amphorina aurantiaca* (A. & H.).
6. *Cratena amœna* (A. & H.).
7. *Galvina cingulata* (A. & H.).
8. *Galvina picta* (A. & H.).
9. *Galvina tricolor* (Forbes).

10. *Coryphella gracilis* (A. & H.)
11. *C. lineata* (Lovén).
12. *C rufibranchialis* (Johnst.).
13. *C. salmonacea* (Couth.).
14. *Facelina drummondi* (Thomp.).

Lomanotidæ.

15. *Lomanotus genei* (Vérany).

Dotonidæ.

16. *Doto coronata* (Gmelin).
17. *D. fragilis* (Forbes).

Dendronotidæ.

18. *Dendronotus arborescens* (Müller).

Tritoniidæ.

19. *Tritonia hombergi,* Cuvier.
20. *T. plebeia,* Johnston.

Dorididæ.

21. *Archidoris testudinaria* (A. & H.).
22. *A. tuberculata* (Cuvier).

Polyceridæ.

23. *Acanthodoris pilosa* (Müller).
24. *A. subquadrata* (A. & H.).
25. *Lamellidoris bilamellata* (Linn.).
26. *Goniodoris castanea,* A. & H.
27. *Idaliella aspersa* (A. & H.).
28. *Ancula cristata* (Alder).

While following Bergh, Vayssière, Trinchese, and other authors in regarding *Coryphella rufibranchialis, C. pellucida* and *C. landsburgii* as synonyms, I have preferred to treat *C. gracilis* as a good species, and also describe *Coryphella salmonacea* as occurring in the British area.

ÆOLIDIA PAPILLOSA (Linn.).

Voyage XCVI. Station. 15. Lat. 54° 30′ N. Long. 3° 59′ E. 25 fathoms. 1 specimen.

Length 2 cm. The colouration almost identical with that of most littoral specimens. The triangular white mark on the head prominent. Oral tentacles of a clear white, spotted with opaque white. Body,

rhinophores and papillæ, dull yellowish white, freckled with brown. Tail very obtuse.

The specimen was found upon a colony of *Alcyonium digitatum.*

ÆOLIDIELLA ALDERI (Cocks).

Voyage XCVI. Station 15. Lat. 54° 30′ N. Long. 3° 59′ E. 25 fathoms. 1 specimen.

Found on *Alcyonium digitatum.* Length about 16 mm.

When first obtained the specimen was taken to be a variety of *A. glauca*, but upon examining it in the Laboratory I found that it belonged to the present species.

Oral tentacles longer than the rhinophores, and white; rhinophores stout, wrinkled, bright orange-red, and very like those of *A. glauca.* Papillæ set in 8 or 9 rows, of a reddish chestnut colour, paler at the bases and tips, and more or less freckled with white.

The "ruff" was not well marked, but the papillæ forming it were paler than the rest. All the papillæ were erected upon irritation. Tail tapering to a fairly fine point.

The radula agreed generally with Alder & Hancock's plate and description. There were 14 plates of a clear yellowish white, tapering gradually; the central tooth rather stronger than in their figure, and the laterals 24 in number.

ÆOLIDIELLA GLAUCA (A. & H.).

Voyage XCV. Station 24. S. edge of the Coal Pit. 13 fathoms. 1 specimen.
Voyage XCVI. Station 18. Lat. 54° 16′ N. Long. 1° 46′ E. 23 fathoms. 2 specimens.

The specimen from XCV—24 was upon *Alcyonium digitatum.*

Those from XCVI—18 were found clinging to the meshes of the beam trawl, but *A. digitatum* occurred commonly in the haul.

All the individuals agreed with Alder and Hancock's specimen in form, but showed considerable variation in their colouration, especially in the colouration of the papillæ.

(*a*) In the specimen from XCV—24 the length was 14 mm. The rhinophores were somewhat wrinkled, short, stout, and tipped with white. Oral tentacles semi-transparent and freckled all over with white. Body and papillæ as in Alder and Hancock's plate. Eyes plainly visible.

(*b*) Those from XCVI—18 measured 35 and 25 mm. in length, respectively.

In both the papillæ were for almost their whole length of a dull green, freckled with opaque white, no red being seen.

In (*a*) the head and body were as figured by Alder & Hancock; in (*b*) the oral tentacles were much paler, and the head and rhinophores of a dull uniform red.

The animals showed little activity, but both crawled on the surface film on several occasions.

E. Hecht (*Contribution à l'étude des Nudibranches*, 1896) says of this species: "Remarquable par la variabilité de sa coloration, qui est parfois plus foncée que celle indiquée par Alder et Hancock, et plus souvent d'un jaune grisâtre."

CUTHONA NANA, A. & H.

Voyage XCII. Station 45. Edge of Sylt Outer Rough. 13 fathoms. Several specimens.

Voyage XCII. Station 46. Edge of Sylt Outer Rough. 13 fathoms. Several specimens.

Voyage XCIII. Station 9. N. of Dogger Rough. 13 fathoms. Several specimens.

Voyage XCIII. Station 19. Bruecy's Garden. 27 fathoms. 6 specimens.

Most of the specimens obtained were small, four of those from XCIII—19 measuring 9, 8, 6 and 4 mm.

All were feeding upon *Hydractinia echinata*.

Those from XCII—45 were upon a large specimen of *Hyas coarctatus*, which was almost covered with a growth of *Hydractinia*. Some nine individuals, mostly small, were clustered upon the under side of the head of the crab, and several others upon the crapace. All were of a transparent white, the papillæ having a light chestnut or pink core.

Those obtained at the other stations were upon *Hydractinia*, encrusting the shells of *Natica monilifera* and *Buccinum*. Leslie and Herdman (*The Invertebrate Fauna of the Firth of Forth*, 1881) also record *C. nana* on *Hydractinia* at "Morrison's Haven," collected by Dr. T. Strethill Wright.

AMPHORINA AURANTIACA (A. & H.).

Voyage XCIV. Station 47. Outer Dowsing Ground. Lat. 53° 28¾′ N. Long. 1° 93′ E. 14½ fathoms. 1 specimen.

Length 1 cm. The specimen differed slightly from Alder and Hancock's plate and description, the rhinophores being wrinkled and slightly shorter than the oral tentacles. The white area below the tips of the papillæ very faint; the animal was damaged, and many of the papillæ were missing from the posterior region.

It was living upon a colony of *Tubularia larnyx*, which was growing upon a large stone. The spawn, which was similar to the figure of Alder and Hancock, was attached to the bases of the *Tubularia*.

CRATENA AMOENA (A. & H.).

Voyage XCV. Station 23. S. edge of the Coal Pit. 24 fathoms. 2 specimens.

The two examples of this most beautiful species were discovered creeping about the base of a colony of *Sertularia argenta*, growing upon a dead valve of *Pecten opercularis*.

Length 6 and 4 mm. respectively.

They differed from Alder and Hancock's plate and description in the following particulars, but otherwise were similar :—

1. The oral tentacles were not much longer than the rhinophores, and were white and without the brown band.
2. There was a prominent dark green mark on the centre of the head, probably due to the jaws showing through the tissues.
3. The red band on the rhinophores was broad, and in one specimen occupied the centre of the organ. In the other specimen the basal half of the rhinophore was red-brown and the upper half white.
4. The foot was more bilobed, and produced into rounded lobes at the sides.

The animals were active and restless, and progressed with ease on a flat surface contrary to Alder and Hancock's surmise.

Papillæ pale green, spotted with white and brown at their bases; a few white spots were present on the head region, but I could not make out any "white tubercles" in that region.

GALVINA CINGULATA; A. & H.

Voyage XCIV. Station 13. Inner Silver Pit. 43 fathoms. 1 specimen. Length 13 mm.

The specimen was in a very perfect condition, and as it differs in several minor points from the plate and description of Alder and Hancock, a detailed description may be of interest. Body dull white, shaded, patched, blotched, and streaked with brown and olive-brown, much darker in the regions from which the papillæ arise.

The rhinophores smooth and very little shorter than the oral tentacles, a band of olive near the tip, and streaks of white down to the base. Oral tentacles similar. Head olive, spotted with white. Eyes not discernible. The region immediately behind the head streaked and lined with dark olive-brown and spotted with white.

Papillæ long, stout, and irregular in outline, set in 9 transverse rows, the first somewhat remote from the others and arising close behind the rhinophores, thickest near the summit, and terminating somewhat abruptly in a small point; the inner rows held more or less curved inwards; 5 or 6 papillæ in each row.

The bases very pale, the "core" of light yellowish brown, irregularly and indistinctly tinged with olive, an olive band near the tip, which is white (due to numerous minute white crowded dots), or sometimes tinged with olive or yellow. A bare space down the centre of the back; posterior region pinkish fawn. Body rather narrow, foot as in Alder and Hancock's plate. Tail shorter than their figure.

The white spots on the body well marked, those on the rhinophores and papillæ less so.

The specimen was living on a branch of *Antennularia ramosa* growing upon a stone brought up by the conical dredge. The hydroid was crowded with yellow gonophores, and the animal was by no means conspicuous when extended with the body parallel with the stem, the general colour and form of the papillæ approximating closely to what was undoubtedly its natural environment.

GALVINA PICTA, A. & H.

Voyage XCII. Station 45. Sylt Outer Ground. 13 fathoms. 1 specimen.
Voyage XCIII. Station 30. Hartlepool Grounds. 30 fathoms. 2 specimens.

The specimens were of the normal colouration, that from CXII—45 was living upon a colony of *Sertularia cupressina*.

GALVINA TRICOLOR (Forbes).

Voyage XCIII. Station 96. Lat. 55° 50′ N. Long. 0° 35′ E. 45 fathoms. 4 specimens.
Voyage XCIII. Station 99. Lat. 55° 48′ N. Long. 0° 49′ E. 45 fathoms. 1 specimen.
Voyage XCIV. Station 11. Inner Silver Pit. 43 fathoms. 1 specimen.
,, XCV. ,, 24. S. edge of the Coal Pit. 13 fathoms. 1 specimen.
Voyage XCVI. Station 18. Lat. 54° 16′ N. Long. 1° 46′ E. 23 fathoms. 1 specimen.

Some variations were observable in the colours of the body and papillæ.

In the younger specimens the yellow band near the tip of the papillæ was paler than in the adults, and in one case it was absent from some of the papillæ, though present in others; when absent the whole tip was white.

In some of the adult specimens the body was brownish and in others of a greenish yellow.

The specimen from XCIV—11 had had a number of the papillæ torn off, and fresh ones were growing in their places.

CORYPHELLA GRACILIS (A. & H.).

Voyage XCIV. Station 45. Lat. 53° 22′ N. Long. 0° 34¾ E. 15 fathoms. 5 specimens.

Voyage XCIV. Station 47. Lat. 53° 28¾′ N. Long. 1° 39′ E. 14½ fathoms. 1 specimen.

XCIV—45. Length of specimens, 8, 7, 7, 7, and 6 mm. respectively. Living on *Antennularia antennina* and *Sertularia argenta.*

Agreed in all particulars with Alder and Hancock's description, as also did the specimen from Station 47, which, however, was living upon *Tubularia larnyx.*

CORYPHELLA LINEATA (Loven).

Voyage XCIII. Station 21. West of Brucey's Garden. 40 fathoms. 3 specimens.

Voyage XCIII. Station 23. Whitby Outer Rough. 36 fathoms. 7 specimens.

Voyage XCIII. Station 25. Whitby Grounds. 34 fathoms. 6 specimens.

" " " 30. Off Hartlepool. 30 fathoms. 1 specimen.

" " " 32. N. of Hartlepool. A few specimens.

" " " 53. Lat. 55° 21′ N. Long. 1° 10′ W. 45 fathoms. 3 specimens.

The colour of the papillæ varies somewhat in shade, lighter or darker chestnut-red or carmine; the white tips also may be either well demarcated, narrower or wider, or may be continued downwards for a little way in streaks and blotches.

The papillæ arise from or about two lateral transparent ridges, which are more prominent in some individuals than others; the first pair of clusters are much the largest, and are somewhat compressed and taper rapidly to the tip.

The posterior portion of the foot is broad, and capable of considerable expansion; the animal attaches itself by this, the rest of the body swinging freely in the water (as in many other species). It can also crawl on the surface film.

The radula agrees with the figure and description of Alder and Hancock.

The food of the species appears to be *Tubularia indivisa* and *T. larnyx.*

CORYPHELLA RUFIBRANCHIALIS (Johnst.).

Voyage XCIII. Station 21. W. of Brucey's Garden. 40 fathoms. 2 specimens.
Voyage XCIII. Station 23. Whitby Outer Rough. 36 fathoms. 5 specimens.
,, ,, ,, 30. Off Hartlepool. 30 fathoms. Common.
,, XCV. ,, 24. S. edge of the Coal Pit. 13 fathoms. 1 specimen.

With the exception of that from XCV—24, all the specimens obtained from the above, and a number of other stations off the coasts of Durham and Northumberland and to the N. of the Dogger Bank, etc., were referred when captured to the *C. pellucida* of Alder and Hancock. In size and external features almost all exactly agreed with the plate and description of those authors, but upon examining the radulæ it became evident that they must all be referred to the present species.

Some 16 specimens were examined from XCIII—21, 23, and 30. Unfortunately specimens from the other stations had not been preserved, so I can only conjecture that they were also referable to this species.

All the radulæ examined agreed very closely, and many were identical with the figures and description of Alder and Hancock. Generally of a yellowish white, the central plate with usually 15 denticles, the central cusp strong; the laterals, as described by Alder and Hancock, "of an acute triangular form with the apex turned outwards;" the denticles on their inner margins, however, very irregular in size and number, in some cases 12 to 14 and of fair size, in others the same number but much smaller, in others again only 7 or 8 might be present upon the upper portion of the tooth.

It is possible that specimens occur without any denticles on the laterals, and although the radula, figured by Alder and Hancock for *C. pellucida*, is of a different shape to any I examined, still the evidence, I think, supports the opinions of Bergh and Vayssière, who unite these species.

One specimen from XCIII—30 had a faint white bifurcating line on the head as in *C. lineata*, and in another from the same station the head region was coloured as in *C. landsburgii* (A. & H.). Oral tentacles and rhinophores amethystine, and tipped with yellowish white; length, half an inch. Both these cases also support the views of Bergh and Vayssière in uniting these species also with *C. rufibranchialis*.

Tubularia indivisa and *T. larnyx* were in every case the habitat of the species, and when crawling along the stems among the colonies the animals very closely resembled their surroundings. Some of the specimens were 4 cm. and many 3 and 3½ cm. in length.

CORYPHELLA SALMONACEA (Couth.).

Voyage XCIII. Station 59. Lat. 55° 31′ N. Long. 0° 36′ W. 47 fathoms. 1 specimen.
Voyage XCIII. Station 89. Lat. 55° 57′ N. Long. 0° 27′ W. 42 fathoms. 2 specimens.
Voyage XCIII. Station 96. Lat. 55° 50′ N. Long. 0° 35′ E. 45 fathoms. Very common.
Voyage XCIII. Station 99. Lat. 55° 48′ N. Long. 0° 49′ E. 45 fathoms. Very abundant.
Voyage XCIII. Station 101. Lat. 55° 48′ N. Long. 1° 40′ E. 40 fathoms. About 100 specimens.
Voyage XCIII. Station 103. Lat. 55° 44′ N. Long. 1° 40′ E. 43 fathoms. Several specimens.
Voyage XCVI. Station 1. Lat. 56° 00′ N. Long. 3° 23′ E. 38 fathoms. 1 specimen.

Length, 20 mm. for the largest; the greater number of specimens, 15 mm. Other measurements of a specimen of 20 mm. in length: height of body, 5 mm.; breadth, 5 mm; length of oral tentacles 5 mm.; rhinophores, 4 mm.; papillæ, 3·5 mm. (for the largest).

Form—Body firm, foot rather narrow, produced at the angles into thin points, tapers gradually to a somewhat obtuse point at the tail.

Oral tentacles broad and thick; rhinophores slightly wrinkled; eyes very small, placed behind the rhinophores; papillæ very numerous, the grouping obscure, continuous almost to the tip of the tail; a bare space continuous from head for three-quarters of the length of the back.

Colours—Body and foot semi-pellucid white; oral tentacles and rhinophores of the same colour, with frequently a line of opaque white down the front, or in the rhinophores confined to the upper third; papillæ reddish brown or fawn coloured, with a very distinct white ring just below the tip, giving an "eyed" appearance when viewed from above; this white ring speedily disappears in preserved specimens. Dorsal area frequently tinged with reddish brown, a faint white line along the dorsal surface of the tail.

Jaws very strong and of a dark horn colour.

Radula triseriate, of 16 to 18 rows, pale yellowish white in colour. Central plate broad, central cusp long and strong, with 7 to 8 denticles on either side, curved inwards and of fair size.

Laterals slender and acute, generally bearing 8 or 9 small and irregular denticles.

Almost all the specimens obtained were adhering to the meshes of the trawl or dredge, so that it is not possible to state its natural

habitat. Few hydroids occurred in any of the hauls. These specimens differ from the majority of *C. salmonacea* in that the lateral teeth have only 8 or 9 denticles on their inner edges, while in typical *C. salmonacea* they are very numerous (*See* Bergh, *Danish Ingolf Expedition*, Vol. II, Pt. 3, pp. 33–34, Pl. IV, Fig. 19; and Pl. V, Fig. 9).

The numerous, closely-set, small papillæ, from among which arise the ill-defined groups of larger ones, were a constant feature in all the specimens examined.

FACELINA DRUMMONDI (Thompson).

Voyage XCIII. Station 7. W. edge of the Hills. 23 fathoms. 1 specimen.
„ „ „ 86. Lat. 56° 20′ N. Long 0° 55′. 36 fathoms. 2 specimens.
Voyage XCIII. Station 89. Lat. 55° 57′ N. Long. 0° 23′ W. 42 fathoms. 1 specimen.
Voyage XCIV. Station 47. Lat. 53° 28¾′ N. Long. 1° 39′ E. 14½ fathoms. 1 specimen.

XCIII—86. Head orange, with white blotches between the rhinophores; back light orange, becoming patchy towards the tail, which was pellucid white, and had a white line to the tip. Oral tentacles long, somewhat wrinkled, orange, the tips lighter and spotted with white. Rhinophores laminated, dark orange, the tip white, and a white line down the front of the tip. Eyes situated in front of the rhinophores in one specimen and behind them in the other. Papillæ run on to the head around the rhinophores; many were missing, but those remaining were of a chestnut-maroon, with a prominent white ring below the pellucid tip, those nearest the rhinophores with a longitudinal white line on the front face, and the white ring absent. Length of animals, 15 and 20 mm.

XCIII—89. The body lighter in colour and semi-transparent. Foot sharply angulated, propodium deeply notched; a white line on the foot angles. Oral tentacles twice the length of the rhinophores. Papillæ dark chocolate colour.

XCIV—47. A young specimen ½ of an inch in length.

Foot angles produced into long fine points. Occurred upon *Tubularia larnyx*.

LOMANOTUS GENEI, Verany.

Voyage XCIII. Station 96. Lat. 55° 50′ N. Long. 0° 35′ E. 45 fathoms. 1 specimen.

Length 14 mm.

The rhinophores were of an orange-yellow colour, stout, and with about 15 closely-set laminæ, the tip produced, truncated, and smooth;

sheaths "calyx like," extending for half the length of the rhinophores, the margin divided into a number of small blunt teeth. Margins of foot rounded.

Body semi-transparent, tinged with pink; viscera yellowish and visible through the body wall. Faint pinkish brown lines on the epipodial processes.

DOTO CORONATA (Gmelin).

Voyage XCIV. Station 45. Lat. 53° 22′ N. Long. 0° 34¾′ E. 15 fathoms. Common.

Voyage XCV. Station 23. Knoll Deeps. 22 fathoms. 1 specimen.

Those from XCIV—45 were living and spawning freely upon *Gemellaria loricata* and *Hydrallmania falcata.*

DOTO FRAGILIS, Forbes.

Voyage XCIII. Station 62. Lat. 55° 31′ N. Long. 0° 19′ W. 36 fathoms. 3 specimens.

Voyage XCIV. Station 13. Inner Silver Pit. 43 fathoms. 1 specimen.

„ „ „ 38. N. of Haisboro L.V. 14 fathoms. 1 specimen.

„ XCVI. „ 20. Lat. 54° 11′ N. Long. 1° 40′ E. 22 fathoms. 1 specimen.

XVIII—62. The three specimens varied in length from ·5 to 1 cm. One was upon *Tubularia larnyx*, and was much darker in colour than the other two, which were living and spawning on a species of *Halecium.*

DENDRONOTUS ARBORESCENS (Müller).

An enumeration of the stations where this species was obtained is scarcely necessary, as it occurred throughout the entire area explored. *Tubularia* would appear to be its general habitat, and it is most plentiful where *Tubularia* is likewise abundant. Three varieties are especially distinguishable.

(*a*) The body transparent or yellowish white, and the dentritic processes opaque white,

(*b*) a uniform, dull, semi-transparent pink,

(*c*) red, with darker red or red-brown blotches.

The last is the most general, and approximates well with the colonies of *Tubularia* on which it is usually found.

More rarely specimens are found with the body much spotted with white. All these varieties are mentioned by Alder and Hancock.

In one or two specimens a number of small wart-like projections were observable, scattered about the dorsal surface, particularly in the region between the rhinophores and the first pair of processes.

Several very young examples were examined, the smallest being 2 mm. in length; in this specimen the dentritic processes were simple, cylindrical, clavate, and incipiently branched in the first pair, which was much the largest; rhinophores plain and unbranched.

TRITONIA HOMBERGI, Cuvier.

This species was taken at a large number of stations.

It appears to be generally distributed, though seldom abundant; it was especially numerous where *Alcyonium digitatum* abounded. The colouration varied from white, yellowish white and grey, to light or very dark brown.

TRITONIA PLEBEIA, Johnst.

Like the last, this species was found wherever *Alcyonium digitatum* was at all abundant, and was generally to be found creeping about the base of a colony, or between the fleshy lobes. Considerable difference exists between the individuals from the white and those from the orange colonies of Alcyonium; those from the white being of a pale hue, and those from the orange a warm orange-brown with darker markings.

ARCHIDORIS TESTUDINARIA (A. & H.).

Voyage XCIII. Station 59. Lat. 55° 31′ N. Long. 0° 19′ W. 47 fathoms. 1 specimen,

Length 45 mm.; general colour dark greenish yellow.

Branchiæ 9, with a dusky fringe Rhinophores short. Warts of two sizes, low and obtuse. Mantle ample, covering the sides and foot. The radula agreed with the figures given by Eliot (*Journ. Mar. Biol. Assoc.*, Vol. VII, 1906, Pl. XI, Fig. 2).

ARCHIDORIS TUBERCULATA (Cuvier).

East Hartlepool. Rocks about low tide mark. 1 specimen.

ACANTHODORIS PILOSA (Müller).

Very common wherever *Alcyonidium gelatinosum* is at all abundant, and is widely distributed.

Varying in size from a few mm. to nearly 5 cm. in length. Usually pure white, sometimes grey, and occasionally brown or dusky. Spawn abundant upon *Alcyonidium gelatinosum.*

ACANTHODORIS SUBQUADRATA, A. & H.

Voyage XCIII. Station 77. Off Holy Island. 32 fathoms. 1 specimen.

The single example obtained agreed exactly with the description and plate of Alder and Hancock.

LAMELLIDORIS BILAMELLATA (Linn.).

Voyage XCIV. Station 47. Lat. 53° 28$\frac{3}{4}$ N. Long. 1° 39′ E. 14$\frac{1}{2}$ fathoms. 1 specimen.

Voyage XCIV. Station 52. Lat. 53° 30′ N. Long. 1° 80$\frac{1}{2}$′ E. 10 fathoms. 3 specimens.

Voyage XCV. Station 24. S. edge of the Coal Pit. 13 fathoms. Fairly common.

Voyage XCVI. Station 24. Lat. 54° 16′ N. Long. 1° 14′ E. 31 fathoms. Fairly common.

All the specimens but one were living among colonies of *Balanus*, upon stones of various sizes.

In colour they were perfectly normal, and agreed so well with their environment as to be extremely difficult to detect, and repeated searching of the colonies of Balanus was necessary to obtain all the specimens present.

The only marked variation was in the case of a specimen living upon a colony of *Alcyonium digitatum*, growing on a stone covered with *Balanus*, on which normally coloured specimens of *L. bilamellata* were living. This one specimen was of a very clear white, the only dark marks being two obscure and shadowy patches on the mantle, and a slight dusky shade on the branchiæ.

The largest specimens were not more than 16 mm. in length. It was observable that the branchiæ increased in number with age.

GONIODORIS CASTANEA, A. & H.

Voyage XCIV. Station 54. The Sole Pit. Lat. 53° 40′ N. Long. 1° 28′ E. 47 fathoms. 1 specimen.

Colour pinkish white, shaded with yellow. Rhinophores with yellowish laminæ and yellow tips.

Cloak more or less warted all over, the central and transverse ridges strongly warted, a double row on the central one.

Jaws showed through the tissues of the head as a broad purple patch. Branchiæ 7, pinkish brown, with a few white spots, especially near the bases.

The upper part of the foot paler than the mantle and with smaller tubercles.

The specimen was living upon a colony of *Botryllus*, which was attached to a large tube of *Sabella pavonina*, and upon which *A. digitatum* was growing. The animal lay in a depression eaten into the colony, to which it approximated very closely in colouration.

IDALIELLA ASPERSA (A. & H.).

Voyage XCIII. Station 77. Off Holy Island. Lat. 55° 44′ N. Long. 1° 40′ W. 32 fathoms. 1 specimen.

In all respects resembled the specimen described by Alder and Hancock.

ANCULA CRISTATA (Alder).

Voyage XCIV. Station 2. N.E. of Sherringham Bank. 11 fathoms. 1 specimen.

Colour a very transparent white; the orange line on the keel very faint.

The linear appendages surrounding the branchiæ tipped with opaque white in about half their number, the rest with the normal yellow tip; they were very irregular in length.

List of Publications Recording the Results of Researches carried out under the Auspices of the Marine Biological Association of the United Kingdom in their Laboratory at Plymouth or on the North Sea Coast from 1886–1907.

THE following list has been classified, so far as practicable, according to subjects, in order that it may be useful for purposes of reference. The list does not include publications recording the results of observations made on material supplied by the Association to workers in different parts of the country, of which a considerable amount is sent out each year.

In attempting to distinguish between economic and more purely scientific publications considerable difficulty has been experienced; indeed such a distinction is in reality impossible, since all researches bearing on the distribution and habits of marine life of any kind have a more or less direct bearing on fishery problems. All papers dealing with the distribution, habits, and young stages of fishes have been included in the economic division, whether the fishes are themselves marketable or not.

June, 1907.

Economic Publications.

FISHES.

1. *General.*

The Natural History of the Marketable Marine Fishes of the British Islands. Prepared by order of the Council of the Marine Biological Association especially for the use of those interested in the Sea-Fishing Industries. By J. T. Cunningham, M.A. With a preface by E. Ray Lankester, M.A., LL.D., F.R.S. London : Macmillan and Co., Ltd., 1896.

The Ovaries of Fishes. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 154.

On the Histology of the Ovary and of the Ovarian Ova in certain Marine Fishes. By J. T. Cunningham, M.A. Quart. Journ. Micr. Sci. XL. 1897, p. 101.

A Contribution to the Knowledge of the Ovary and Intra-ovarian Egg in Teleosteans (with Plates XI. and XII.). By W. L. Calderwood. Journ. M.B.A. N.S. ii. 1891–92, p. 298.

Observations on Ovarian Ova and Follicles in certain Teleostean and Elasmobranch Fishes. By W. Wallace, M.A. Quart. Journ. Micr. Sci., vol. xlvii. p. 161.

A Record of the Teleostean Eggs and Larvæ observed at Plymouth in 1897. By E. W. L. Holt and S. D. Scott, B.A. Journ. M.B.A. N.S. v. 1897–99, p. 156.

Studies on the Reproduction and Development of Teleostean Fishes occurring in the neighbourhood of Plymouth (with Plates I.–VI.) By J. T Cunningham, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 10.

On some Larval Stages of Fishes (with Plates III. and IV.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 68.

On Some Disputed Points in Teleostean Embryology. By J. T. Cunningham, M.A. Ann. and Mag. Nat. Hist. 1891.

Recherches sur la Reproduction des Poissons osseux. Par E. W. L. Holt. Ann. Mus. Hist. Nat. Marseille, v., 1899.

Preliminary notes on the Reproduction of Teleostean Fishes in the South-Western District. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 41.

Notes on the Reproduction of Teleostean Fishes in the South-Western District. By E. W. L. Holt and L. W. Byrne, B.A. Journ. M.B.A. N.S. v. 1897–99, p. 333.

Report on the Eggs and Larvæ of Teleostean Fishes observed at Plymouth in the Spring of 1902. By F. Balfour Browne, M.A. Journ. M.B.A. vi. 1903, p. 598.

Notes on the Reproduction of Teleostean Fishes in the South-Western District. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 107.

Report on a Collection of Very Young Fishes obtained by Dr. G. H. Fowler in the Faeroë Channel. By E. W. L. Holt. Proceed. Zool. Soc., London. 1898, p. 550.

The Rate of Growth of some Sea Fishes and their Distribution at Different Ages. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 95.

On the rate of Growth of some Sea Fishes and the Age and Size at which they begin to breed. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 222.

Report on the Probable Ages of Young Fish collected by Mr. Holt in the North Sea. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 344.

On the Relation of Size to Sexual Maturity in Pleuronectids. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. ii. 1891–92, p. 363.

On the Relation of Size to Sexual Maturity in Round-fish. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 78.

On the Relations of the Generative Organs and of the Sexes in some Fishes. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 28.

Hybridism in Marine Fishes. By H. M. Kyle, D.Sc. Journ. M.B.A. vi. 1903, p. 623.

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Destruction of Immature Fish. By G. C. Bourne, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 153.

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The Immature Fish Question. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 54.

Growth and Distribution of Young Food-fishes. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 272.

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Notes on the Fishing Industry of Plymouth. By Walter Heape, M.A. Journ. M.B.A. Old Series. No. 1. 1887, p. 45.

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Notes on Rare or Interesting Specimens (*Clupea alosa*, *Auxis Rochei*, *Thynnus thynnus*, *Myliobatis aquila*). By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 274.

North Sea Investigations. Preliminary. By E. W. L. Holt. Journ. M.B.A. N.S. ii. 1891–92, p. 216.

On the Territorial Fishing Ground of Scarborough and its Neighbourhood. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 176.

On the Iceland Trawl Fishery, with some Remarks on the History of the North Sea Trawling Grounds. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 129.

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Observations at Sea and in the Markets — Grimsby, Scarborough, Hull, Lowestoft. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 108.

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General Report on the Fishery Investigations. By Walter Garstang, M.A. Internat. Fish. Investigations. Mar. Biol. Assoc. Report I. 1902–03 (Cd. 2670). 1905, p. 1.

Report on Experiments with Marked Fish during 1902–03. By Walter Garstang, M.A. Internat. Fish. Investigations, Mar. Biol. Assoc. Report I. 1902–03 (Cd. 2670). 1905, p. 13.

Report on the Trawling Investigations, 1902–3, with especial reference to the distribution of the Plaice. By Walter Garstang, M.A. Internat. Fish. Investigations, Mar. Biol. Assoc. Report I. 1902–03 (Cd. 2670). 1905, p. 67.

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Breeding of Fish in the Aquarium. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 195.

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On the First Successful Experiment with Importation of European Sea Fishes to Australian Waters. By H. C. Dannevig. Fisheries of New South Wales. Annual Report for 1902, II.

The Sense-Organs and Perceptions of Fishes, with Remarks on the Supply of Bait (with Plate XX.). By W. Bateson, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 225.

Modes in which Fish are affected by Artificial Light. By W. Bateson, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 216.

Experiments on the Production of Artificial Baits. By Frank Hughes. Journ. M.B.A. N.S. ii. 1891–92, pp. 91 and 220.

Notes on How Fish Find Food. (Report on the occupation of Table.) By Gregg Wilson, M.A., B.Sc. Report Brit. Assoc., 1893, p. 548.

Notes on the Invertebrate Fauna and Fish-food of the Bays between the Start and Exmouth. By R. A. Todd, B.Sc. Journ. M.B.A. vi. 1903, p. 541.

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2. *The Eel Family.*

The Breeding of the Conger. By J. T. Cunningham, M.A. Journ. M.B.A., Old Series, No. 2. 1888, p. 245.

On the Reproduction and Development of the Conger. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 16.

On a Specimen of *Leptocephalus Morisii.* By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 73.

Sudden Colour-changes in Conger. By W. Bateson, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 214.

The Larva of the Eel. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 278.

The Reproductive Maturity of the Common Eel. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 87.

Eels and Sticklebacks in Sea-water. By W. L. Calderwood. Journ. M.B.A. N.S. ii. 1891–92, p. 77.

Note on *Muraena helena*, Linn. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 91.

3. *The Herring Family.*

Anchovies in the English Channel (with an illustration in the text). By J. T. Cunningham, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 328.

Probable Relation between Temperature and the Annual Catch of Anchovies in the Schelde District (with Plate XXIV.). By G. H. Fowler, B.A., PH.D. Journ. M.B.A. N.S. i. 1889–90, p. 340.

Experiments on the Relative Abundance of Anchovies off the South Coast of England. By W. L. Calderwood. Journ. M.B.A. N.S. ii. 1891–92, p. 268.

The Migration of the Anchovy. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 300.

Ichthyological Contributions. iv. Growth of Young Herring in the Thames Estuary. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891-92, p. 330.

On the Occurrence of Large Numbers of Larval Herrings at the Surface. By Matthias Dunn. Journ. M.B.A. N.S. v. 1897-99, p. 184.

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Notes on Herring, Long-line and Pilchard Fisheries of Plymouth. By W. Roach. Journ. M.B.A. N.S. ii. 1891-92, p. 180.

The Spawn of the Pilchard. By J. T. Cunningham, M.A. Journ. M.B.A. Old Series, No. 2. 1888, p. 247.

The Reproduction and Growth of the Pilchard (with Plate X.). By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891-92, p. 151.

Year-old Pilchards. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891-92, p. 398.

The Life History of the Pilchard. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893-95, p. 148.

4. *The Salmon Family.*

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Grayling and Loch Leven Trout in Salt Water. By W. L. Calderwood. Journ. M.B.A. N.S. v. 1891-92, p. 76.

5. *Flat-fish Family.*

Diagnostic characters in Flat-fishes. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. v. 1893-95, p. 247.

The Development of the Egg in Flat-fishes and Pipe-fishes. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893-95, p. 258.

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Reproductive Organs of the Common Sole. By J. T. Cunningham, M.A. Journ. M.B.A. Old Series, No. 2. 1888, p. 248.

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Note on *Pleuronectes microcephalus*, Donov. By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 121.

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Note on some Supposed Hybrids between the Turbot and the Brill. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 292.

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I.—UNIVERSITIES, UNIVERSITY COLLEGES, AND RESEARCH LABORATORIES.

Department of Comparative Anatomy, Oxford.
Geological Laboratory, Oxford.

Zoological Laboratory, Cambridge.
Balfour Laboratory, Cambridge.
The Botany School, Cambridge.

The University of London.
Bedford College for Women, London.
Birkbeck College, London.
Charing Cross Hospital Medical College.
Guy's Hospital Medical College.
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BY

J. T. CUNNINGHAM, M.A.,

FORMERLY FELLOW OF UNIVERSITY COLLEGE, OXFORD;
NATURALIST ON THE STAFF OF THE MARINE BIOLOGICAL ASSOCIATION.

With Preface by

E. RAY LANKESTER, M.A., LL.D., F.R.S.,

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BY

ANDR. FRED. HÖST ET FILS,

COPENHAGEN.

Plankton Studies in Relation to the Western Mackerel Fishery.

By

G. E. Bullen.

With Six Charts (Plates XVIII–XXIII), two Figures in the Text and Tables I–V.

I. METHODS.

THE researches here described extended for intermittent periods over the years 1906 and 1907, and were primarily intended to embrace inquiry into the food problem of Pilchard, Herring, and Mackerel frequenting the western part of the English Channel. The observations now recorded form, therefore, a part of a wider series.

Most of the information referring to the condition of the fishery throughout the spring season of the two years was collected at Newlyn and Plymouth, by systematic inquiry amongst the fishermen. Other information was derived from the market reports of the *Fish Trades Gazette* and other journals, and from Mr. Mathias Dunn of Newlyn, who kept the fishery constantly under observation.

The samples of plankton and stomach material were obtained from various sources. Some were taken by myself at sea from fishing-boats or from the *Oithona*, others by fishermen; whilst a good deal of the stomach material was got from systematic collections made at Plymouth and Newlyn from catches landed at those ports. In addition to the plankton samples mentioned above, certain samples taken at the western stations during the international cruises were also examined and the results utilized.

The plankton was collected for the most part by a compound townet embodying in its construction Swiss bolting silk of two sizes of mesh, viz. (*a*) 18 holes per 1 cm., the average length of a hole being ·056 cm. and the average breadth being ·036 cm., and (*b*) 70 holes per 1 cm. The surface hauls were usually made for ten minutes. The contents of the net were filtered through a net-bag constructed of the fine silk mentioned above, and the product preserved in 5 % formalin.

In certain cases the samples were collected by two separate nets, of coarse and fine mesh respectively.

As this paper does not deal with plankton other than in its direct bearing upon mackerel food, it has been considered desirable, for purposes of easy reference, to include the surface hauls with those taken from bottom to surface (oblique) under one column for each position noted on the Plankton Tables (Tables I, II). In thus combining the analyses of the surface and oblique hauls, it may be mentioned that the comparative signs (which are those adopted in the International Plankton Investigations) placed against the Phytoplankton species are those derived from the analysis of the surface haul, whilst for Zooplankton the higher of the two values recorded for the surface and oblique hauls is used.

In the determination of the plankton samples, a general examination was first made under magnification $\times 48$ and $\times 160$ in a shallow trough. The phytoplankton was subsequently examined under cover-slip with higher powers, $\times 520$ to $\times 824$, etc.

In the greater number of cases six stomachs were collected from every catch and preserved in 10 % formalin. The contents of each were subsequently washed out into Petrie dishes and examined in a similar manner to that described for plankton. The whole of the sample, unless very bulky, was examined. Other modifications of detail with reference to stomach samples are explained under a later heading, page 273.

My thanks are largely due to Dr. E. J. Allen, who has materially assisted me throughout the investigation and in the preparation of this paper; also to Mr. Mathias Dunn, for much valuable help in the collection of observations and material. I here also desire to express my thanks to Mr. Howard Dunn, Mr. D. J. Mathews, Dr. L. H. Gough, and Mr. W. Bygrave, for assistance in the collection or identification of material, and to Mr. A. E. Hefford for help in the preparation of this paper.

II. THE WESTERN SPRING MACKEREL FISHERY.

The factors, which influence the inshore migration of mackerel in greater or less abundance, have long been the subject of inquiry. That the purpose of spawning is the primary object of such migration has been admitted, but it still remains to show reasons for the greater or less extent of this migration, which from a commercial standpoint, under the present system of drift fishing, is equivalent to a good, bad, or indifferent season. Many previous authors have shown that

plankton forms the main food of mackerel during the shoaling season, and the examination of more than four hundred stomachs of mackerel taken in the British Channel and extreme western part of the English Channel, during the present investigations (1906–7), has shown agreement with this result. As suggested by several previous authors on the subject, it appears possible that from a study of this food some light may be thrown upon the factors which govern the fluctuations in the mackerel fishery during the spring shoaling season. The object of this paper, therefore, is to show, from the information and observations at our disposal, whether there is a demonstrable correlation between the distribution of plankton or mackerel food, and the extent of migration. It has already been stated that over four hundred stomachs have been examined during the present researches. These were taken in 1906–7 from fish caught in the Bristol Channel and in the English Channel from Plymouth to west of Scilly, during the three months which constitute the more important part of the spring fishery, viz. April, May, and June. The result of the analyses of these stomachs will be found in the Plankton and Food Tables which are appended. From an examination of these tables it will be seen that on no occasion has an instance occurred of material, other than plankton, being observed in the stomachs of fish caught during the shoaling season in the extreme western part of the area under consideration. In the eastern part, however (see Table V), it will be seen that the plankton forming the principal food was gradually supplemented, as the season advanced, with young fish and adult *Crystallogobius nilsoni*.

From information derived from the weekly market reports published in the *Fish Trades Gazette*, and from statements made to me by local fishermen at Plymouth and Newlyn, it would appear that, although drift fishing had been carried on in the Bristol Channel and elsewhere since the beginning of February until April in 1906 and 1907, the catches made were irregular and comparatively small. Fishermen and others agreed in stating that this was due to the fact, that there appeared to be no regular shoaling at the surface during these three months.

That mackerel did occur, however, in the inshore waters at this time at the surface is evinced by the fact that fair catches of hook fish were made constantly during the early months of the two years, as shown by the market reports, and by the writer's personal observations.

Fishermen seem to be agreed that shoaling mackerel will not take a bait: and a consideration of the above facts tends to suggest that in

these early spring months mackerel may be present at the surface but are disseminated over a wide area. A careful comparison of the plankton results for the February cruises, shown in the *Bulletins Conseil International pour l'exploration de la Mer*, shows that, at the western mid-Channel and Bristol Channel stations (E. 5 and E. 6, the only two falling within the fishing area), plankton generally has reached a minimum in comparison with other quarterly results. It is desirable at this point to state that, for the purpose of comparison in this and other cases, an arbitrary numerical value was substituted for the comparative signs employed in the tables, viz. + = 10, c = 100, cc = 500, the signs "r" and "rr" being disregarded. In the present instance comparison was made for all the years since the commencement of the international investigations, and this condition appeared to be invariably the same. This point is further supported by certain observations taken during the present investigations (Nos. 2, 3, 4, 5, 6, Table I).

These two main facts considered together cannot, however, be offered as sufficient evidence that mackerel do not shoal closely at the surface until there is a sufficiency of plankton to form food for their support without much individual effort, especially in view of the fact that mackerel are known to be shoaling densely at the bottom off Start Point in the early part of the year, and, as far as our present observations extend, are feeding there upon plankton. Possibly, however, it may be suggested reservedly that a lack of plankton may exercise a retarding influence upon the shoaling of fish already at the surface, which are disseminated over a wide area, of the presence of which evidence has already been given. Further, attention has already been drawn to the fact that in the Plymouth to Lizard area in 1907 larger food material was observed, in gradually increasing quantity as the season advanced, from the end of April onwards. Throughout July, 1907, from the writer's personal observations, the plankton in the Plymouth area was observed to decrease very materially in quantity. In the previous month, the tow-nettings brought to the Laboratory at Plymouth from within and outside the Sound for the use of students, and for the Plymouth plankton records taken weekly, were composed mainly of *Temora longicornis* in extreme abundance. During the first few days of July, within the first week, the Copepod in question, from being extremely abundant, rapidly disappeared from the tow-nettings, leaving the samples almost clear, for the time being, of animal life. No plankton observations were obtained from the western area during July, 1907; but, confining our attention to the Plymouth to Lizard area, it appeared that from all reports the shoals broke up at about this time and the hand-lining season commenced. It may, therefore, be sug-

gested, that, until individual effort on the part of the fish to secure food becomes necessary, the mackerel remain in shoals.

These results tend to support the theory that mackerel feed upon plankton only when shoaling.

Owing to a certain general similarity in the samples examined, it was found possible to tabulate the results of the analyses of the stomach material. These are given in the Plankton and Food Tables (III, IV, and V) which are appended. From nearly every position noted therein the contents of six stomachs were examined, and, by a system of adopting the highest comparative symbol placed against the different species throughout the series, a single sample was formed. This, in certain instances, is shown for comparison with a plankton sample collected on the same position as that from which the fish themselves were derived.

It has proved convenient to arrange the results in three separate tables, viz. Western Area, 1906; Western Area, 1907; and Plymouth to Lizard Area, 1907. Lack of observation in this latter area in the earlier year has prevented the formation of a separate table for 1906.

It will be seen that only those principal species, which occurred more or less regularly in the stomach contents, have been included in the tables. These comprise seven species of Copepods, viz. *Acartia clausi*, *Calanus finmarchicus*, *Centropages typicus*, *Metridia lucens*, *Paracalanus parvus*, *Pseudocalanus elongatus*, and *Temora longicornis*. An examination of the tables will show that of these species *Calanus finmarchicus*, *Pseudocalanus elongatus*, and *Temora longicornis* are the most important. The other species, although persistently occurring in stomach contents, are hardly of sufficient importance for purposes of comparison.

In addition to the Copepods there are included in the tables, Zoeae, *Sagitta bipunctata* and *Oikopleura dioica*. These species, together with the Copepods, constitute the principal forms of zooplankton observed in the stomach contents.

For the Plymouth to Lizard area it was found necessary to include young fish, or *Crystallogobius*. The last item for consideration, which is noted on every table as "Phytoplankton, chiefly *Phaeocystis globosa*," refers to the material largely found in mackerel stomachs in the early part of the season. This, upon examination, in many instances proved to be diatom detritus, consisting of the shells, spines, chromatophores, and the jelly-like substance associated with them, forming in a majority of cases a glairy mass of a dark green tint.* Associated with this material in a number of instances was a certain quantity of *Phaeocystis*

* For the exact diagnosis of the nature of this material the writer is indebted to Mr. A. J. Mason-Jones.

globosa, the exact proportion of which it was found impossible to gauge. In certain samples, however, owing to the absence of diatoms and other protophyta (Samples 68, 69, 93, 94, Tables III, IV), it was found possible to estimate the amount of *Phaeocystis* with more probability.

It may be mentioned that Cunningham,* in describing the early spring food of mackerel, remarks, "In some [stomachs] there occurred a quantity of the green slimy vegetable matter, which was then abundant in the sea."

During the examination of certain series of stomachs, instances have occurred where the contained food was deposited in layers (Samples Nos. 94, 120, 121, 123, 124, etc., Tables IV, V). Farran (*Report on Sea and Inland Fisheries, Ireland*, 1901, Part II, p. 122) records the same thing, and Mr. W. M. Tattersall informed the writer that he has frequently observed a similar condition in mackerel from the west of Ireland. Such a state of the stomach contents is specially obvious where the Pteropod *Limacina retroversa* (Flem.) occurs together with one or more species of Copepods, the dark colour of the former contrasting sharply with the bright orange tint of the latter. It has often been suggested that certain plankton organisms occur in shoals of varying extent. Now it is interesting to note in this connection, that many fishermen think that shoaling mackerel, when feeding, scarcely move at all, beyond maintaining their position against the current. The theory of the fish feeding, therefore, first in one shoal of plankton organism and then in another as they pass, may be suggested as an explanation of this phenomenon. The fact might also be due to the fish swimming first in one and then in another layer of water.

By an examination of the Food and Plankton Tables it will be seen that the plankton organisms occurring in the stomach contents are common also to tow-nettings taken on the same position. In a majority of cases also, the relative proportions of individual species are similar in both, or nearly so. Occasionally differences occur. But in the examination of the large mass of material which is generally found in a mackerel stomach when plankton is abundant, it is often difficult to decide the comparative proportion of one species to another. This fact, together with that of the method of treatment already explained (see p. 273), will account for the differences which are occasionally shown between the analyses of stomach contents and those of plankton samples from the same locality.

Although, however, certain species occurring in the tow-nettings are

* *Marketable Marine Fishes*, p. 313.

observed in the stomach material of fish from the same position, an exhaustive examination of a fair number of stomach samples has failed to show the presence of the same variety of organisms in the stomach, as occur in the tow-nettings taken on the same positions as the mackerel. Possibly this fact may be offered as additional evidence in support of the food-layer theory already mentioned.

In the early part of April, 1906, as in the two preceding months, an unprofitable fishery had been carried on in the Bristol Channel by the greater number of the steam drifters. From fishermen's reports this condition had, it appeared, continued since the commencement of the season without a single period of improved fishing. On the 20th of April, however, some good shoals were struck to the south-west of the Wolf by the sailing fleet. The greater number of the steam drifters at once left the Bristol Channel and commenced fishing in a semicircle to the south and south-west of Scilly. The result was that moderate but regular catches of ten thousand down were landed from this area, the fishing although light being general. The stomach contents of samples of these fish did not differ very materially from those of Bristol Channel fish (see Samples Nos. 66, 67, Table III).

A line of plankton samples was taken at this time from Plymouth to the fishing area south-west of the Wolf, the chief aim being the determination of the relative quantities of zooplankton and phytoplankton* present on the fishing area and adjacent waters. The analyses of the tow-nettings taken on 23rd and 24th April during this cruise (see Samples Nos. 11–20, Table I) are interesting when viewed in relation to the distribution of shoaling mackerel at the time. Briefly summarized, it appeared that from Plymouth to the Lizard phytoplankton in every example was in excess of zooplankton (Samples Nos. 11, 12, 13, and 20, Table I). In the single position in Mount's Bay where tow-nettings were taken this was also the case (Sample No. 19, Table I), whereas in samples taken, on the approach to the fishing area and actually on the ground (Samples Nos. 14–17), there was a rapid decrease in phytoplankton, leading to a reverse of the former condition, i.e. to an excess of zooplankton over phytoplankton. It may be mentioned that the excess of phytoplankton over zooplankton was largely, though not entirely, due to the presence in the samples of large quantities of *Phaeocystis globosa*, Scherffel.

* Throughout this paper the word "phytoplankton" must be understood as referring to the larger organisms, such as are recorded in the plankton tables of the International Bulletin. No investigations have been made on the minute plankton organisms which Lohmann has included under the term "microplankton."

From a comparison of the tables it will be seen that the reverse condition was not brought about entirely by the decrease of the *Phaeocystis*, but also by the increasing number of the Copepods in the samples.

During this cruise, through lack of time, only one position could be worked in the Bristol Channel (Sample No. 18, Table I), which showed phytoplankton in excess of zooplankton. The same condition was observed in a sample taken at Sevenstones five days later. The positions of the stations on this cruise and the general distribution of samples taken during April, 1906, can be readily understood on reference to the Distribution of Species Chart No. 1.

Throughout the early part of April, 1907, from the fishermen's reports it appeared that fairly regular catches had been landed from the Bristol Channel south-west of the Wolf, and also from twenty to thirty miles S.W. of the Lizard. Many fishermen declared, however, that the water lying within a ten-mile or wider limit from the coast from off Plymouth to Land's End, was in that particular condition which they termed "stinking," and of a most unsuitable condition for the presence of mackerel.*

In order to obtain observations in this affected area, and also to trace the varying proportions of zooplankton and phytoplankton on the fishing ground, a cruise was taken from Plymouth to ten miles S.W. of the Wolf, and from thence to twenty miles north of the Longships, somewhat earlier than in 1906, viz. April 16th, 17th. The analyses of the tow-nettings taken (see Samples Nos. 41–8, Table II) show a somewhat similar condition to that observed in 1906, with certain important exceptions. The main differences lie in the excess of phytoplankton extending farther westward past the Lizard (see Samples Nos. 41–5, Table II). This condition was largely due to *Phaeocystis;* zooplankton occurring in excess of phytoplankton only in the sample taken farthest west, viz. ten miles S.W. of the Wolf (No. 48, Table II). A more important feature, however, appears to lie in the conditions observed in the Bristol Channel samples (Nos. 46, 47, Table II), where zooplankton occurred decidedly in excess of phytoplankton. For a synoptic view of these observations, showing the positions of stations, the reader is referred to Distribution of Species Chart No. IV.

Now in drawing a comparison between the condition exhibited by the plankton and that by the fishery in April 1906 and 1907, it will be seen that in the former year, phytoplankton appearing in excess of zooplankton in the Bristol Channel, the fishery there was unprofitable; whereas the reverse obtaining S.W. of the Wolf, fair catches were

* See note on "Stinking Water," p. 289.

made there. In 1907, on the other hand, zooplankton was in excess of phytoplankton both in the Bristol Channel and also to the S.W. of the Wolf, in both of which areas good fishing was obtained. In considering these observations further, it is interesting to find that the most profitable fishing grounds lay outside the area in which phytoplankton predominated, which suggests that mackerel during the shoaling season prefer an animal to a vegetable diet, and may be met with in quantity where such food is abundant.

Further consideration of the Distribution of Species Charts IV to VI shows wider eastward distribution of shoaling mackerel as the season proceeded in 1907.

An examination of the Plankton Tables Nos. I and II shows, moreover, that throughout the season, during 1906, phytoplankton was always in evidence, whereas in 1907 it entirely disappeared from the beginning of May onward until the close of the season. The official statistics of monthly landings, published by the Board of Agriculture and Fisheries show that the fishery in 1906 was phenomenally bad, whereas that of 1907 was very good.

From these two facts it may be suggested that excess of phytoplankton in inshore waters retards or rather limits the eastern migration of the shoals first appearing west of Scilly.

An examination of the official statistics of mackerel landings serves to show that, in the month of May, the quantity of mackerel caught has reached a maximum for the four months forming the more important part of the spring fishery. The following table shows the figures from 1901–7 inclusive. The figures given represent the landings on the south and west coasts of England and Wales, which are significant for the western fishery, since comparatively few mackerel are taken elsewhere during the months dealt with.

Table showing Official Returns of Mackerel landed on the south and west coasts of England and Wales, from March to June inclusive, in the years 1901–7.

TOTAL IN HUNDREDWEIGHTS.

	1901.	1902.	1903.	1904.	1905.	1906.	1907.
March	23,340	8,145	22,492	78,866	63,570	9,260	18,769
April	39,041	73,384	60,190	62,241	152,972	28,779	43,107
May	169,020	169,857	152,753	199,884	378,157	108,273	222,151
June	70,005	77,889	65,005	108,822	53,215	49,743	57,383

As these figures are taken over a fair number of years it may be assumed that during May, under normal conditions, the fishery is at its height. In May also the maximum number of boats are generally

fishing, and during the latter part of the period considered there is no reason to suppose that the number of boats has greatly altered. The fluctuation, as shown by the official figures, in consideration of the usual fair-weather conditions during this month, is less liable to be influenced by causes other than the greater or less extent of migration.

On reference to the above table it will be seen that in May, 1906, the landings touched a minimum for the seven years; whereas, although the figures in no way compare with those of 1905, the May landings for 1907 are suggestive of a good season. The good May fishing of 1907 as opposed to the bad of 1906 forms a useful comparison when we come to consider plankton conditions of the same period in these two years.

From an examination of the daily market reports published in the *Fish Trades Gazette*, it would appear that in 1906 the fishery was gradually improving throughout May until the last week, when, after a short period of improved conditions, it began rapidly to decline, and remained depressed until the end of the season.

In 1907, from information derived from the same source, and from observations taken at Newlyn by Mr. W. Bygrave, it appeared that heavy landings of mackerel took place during the first and second weeks in May. The market was several times glutted; and there is every reason to suppose that, had not a short spell of bad weather intervened, in which the men temporarily lost sight of the shoals, the landings would have been considerably greater than they appear to be from the official statistics. However, despite the unfavourable comparison between the figures for May, 1905, and those of 1907, from all accounts there is every reason to consider the latter year to have been an excellent season.

In reviewing the plankton conditions generally, it should first be pointed out that throughout May, 1906, phytoplankton was present in fair quantity in every sample taken during the month on the fishing grounds (see Table I). In 1907, on the other hand, it had almost completely disappeared, and as may be seen from the Plankton Tables (Table II), zooplankton was represented by merely a few species of Copepods in extreme abundance. The comparative symbol "cc" shown on the tables for certain samples (Nos. 52, 53, 54, 55) hardly sufficiently indicates the large quantities of the species occurring in the sample.

In comparing the plankton conditions during May of these two years, it may be mentioned that a far greater number of observations were taken in 1907 than in 1906. It is desirable, therefore, in draw-

ing a close comparison, to consider only such observations as are common to the two years. These are furnished by the analyses of plankton samples taken at the mid-Channel and Bristol Channel stations (Stats. E. 5 and E. 6) during the May cruises of the International Plankton Investigations.

By the same method of comparison as adopted for other similar cases (see page 272) a curve was formed, showing the fluctuation of the principal zooplankton forming mackerel food. This curve (Fig. 1)

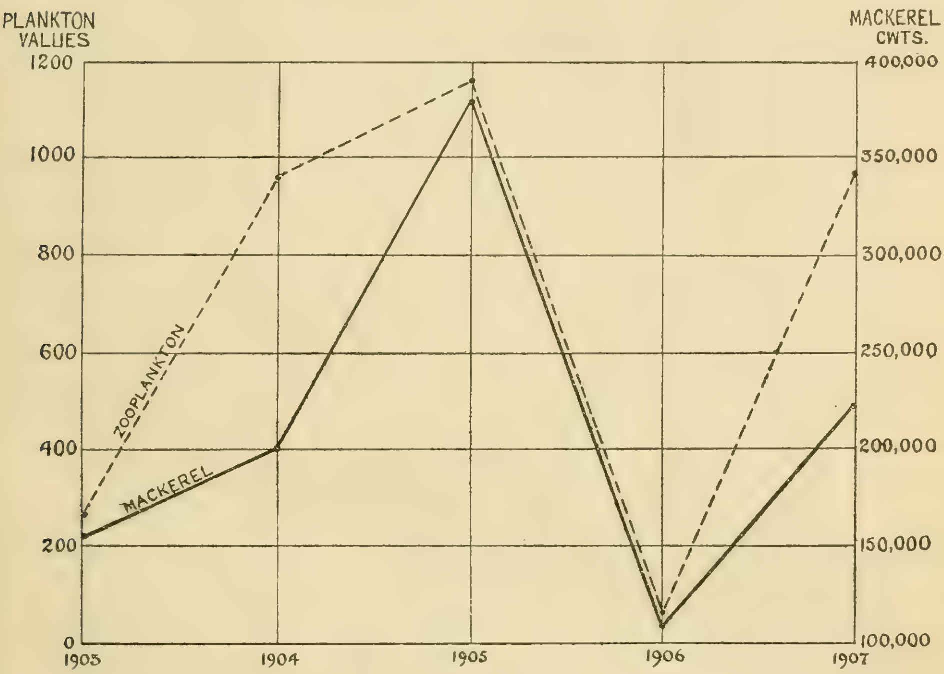


Fig. 1.—Curves showing, for the month of May, fluctuations in the quantities of mackerel landed, and of zooplankton observed at Stations E. 5 and E. 6.

Zooplankton : mean between Stations E. 5 and E. 6 for May—Dotted line.
Mackerel landed during May—Continuous line.

shows the results of a mean between the analyses of the samples taken in surface hauls at the two stations, the following species only being taken into consideration: *Acartia clausi*, *Calanus finmarchicus*, *Centropages typicus*, *Paracalanus parvus*, and *Pseudocalanus elongatus*.

TABLE SHOWING FLUCTUATION OF PRINCIPAL ZOOPLANKTON AT STATIONS E. 5 AND E. 6.

MAY CRUISES. YEARS 1903–7 INCLUSIVE. SURFACE HAULS ONLY.

FROM THE INTERNATIONAL BULLETINS.

The first column shows the comparative value sign, the second the adopted numerical value.

	1903				1904				1905				1906				1907			
	E. 5		E. 6		E. 5		E. 6		E. 5		E. 6		E. 5		E. 6		E. 5		E. 6	
Species.																				
Acartia clausi	–	–	c	100	–	–	c	100	r	–	+	10	r r	–	r	–	c	100	c c	500
Calanus finmarchicus	c	100	c	100	c c	500	c c	500	c c	500	c	100	+	10	r r	–	c c	500	c	100
Centropages typicus	+	10	–	–	r	–	+	10	c c	500	r r	–	–	–	–	–	c	100	c	100
Paracalanus parvus	r	–	r	–	c	100	c	100	c	100	c c	500	+	10	r r	–	+	10	r	–
Pseudocalanus elongatus	c	100	c	100	c	100	c c	500	c	100	c c	500	c	100	r r	–	c c	500	+	10
Total num. value		210		300		700		1210		1200		1110		120		0		1210		710,
Mean value	255				955				1155				60				960			

In order to form a wider comparison the results obtained from all the May cruises since the commencement of the International Investigations in 1903 have been included in the present curve.

When compared with the mackerel landings for May as provided by the official statistics, it will be seen that the correlation between fluctuation of zooplankton and that of the fishery is very marked. This would tend to support the suggestion that when zooplankton is in abundance on the fishing grounds mackerel are numerous.

As already mentioned many more plankton observations were taken during May, 1907, than in the same month of 1906, and as such were actually derived from the fishing area, west and south-west of Scilly (see Samples Nos. 52–55, Table II), they are of value, tending as they do wholly to support the evidence already cited. At every position within the fishing area the samples taken during a ten-minute surface haul were bulky, being composed for the greater part of two or three species of Copepods, viz. *Acartia clausi*, *Calanus finmarchicus*, and *Pseudocalanus elongatus*, the two latter more particularly, to the almost complete exclusion of other organisms. At one position west of Scilly (S. 52, Table IV), a ten-minute surface tow-netting more than half filled a sample jar of capacity approximately 300 cc. with these two species, in comparatively even proportion. In connection with this fact it may be mentioned that a steam drifter fishing ten miles west of this position on the same night (May 16, 17) landed four lasts of fish at Newlyn the next morning.

It is perhaps unnecessary to cite further instances of a similar character. The Food and Plankton Tables and Fluctuation Curve

speak for themselves in support of the theory that the quantity of zooplankton occurring on the fishing grounds materially affects the fishing; the more food the more fish, and *vice versa.*

Before leaving the consideration of the present matter, it is desirable to draw attention to the relation of phytoplankton to zooplankton during May, for the years 1903–7 inclusive. This can best be done by an examination of a curve showing the fluctuation of phytoplankton at the same stations and formed by the same method (Fig. 2).

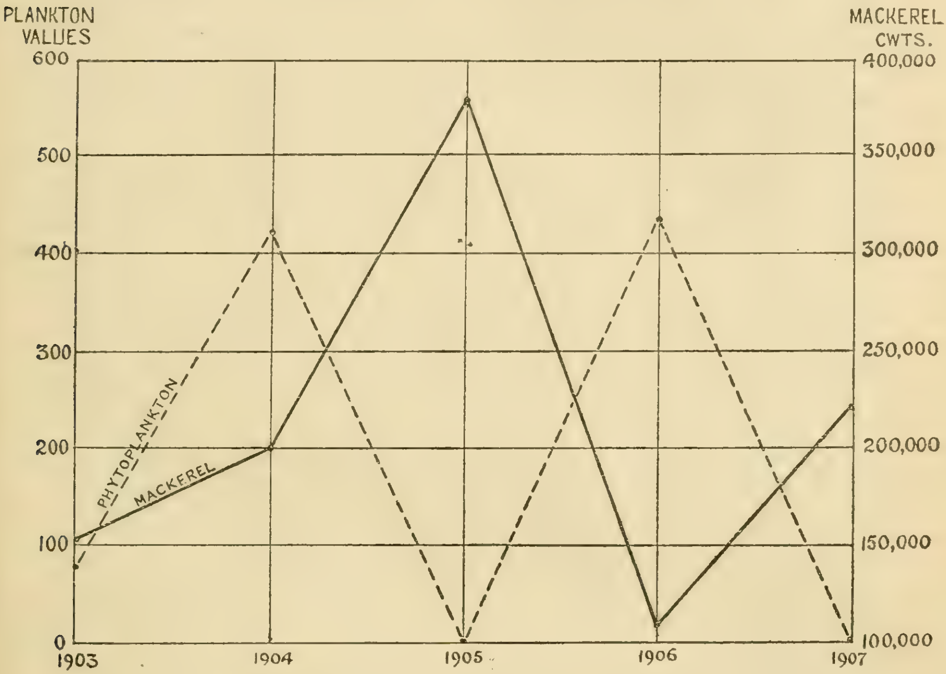


FIG. 2.—Curves showing, for the month of May, fluctuations in the quantities of mackerel landed and of phytoplankton observed at Stations E. 5. and E. 6.

Phytoplankton: mean between Stations E. 5 and E. 6 for May—Dotted line.
Mackerel landed during May—Continuous line.

In the present example, however, it was found necessary to take every species of phytoplankton into consideration. In this it will be seen there appears to be almost a direct inversion of the zooplankton curve. There is an exception, however, in 1903, in which year plankton generally is low.

We have seen that there appears to exist a marked correlation between fluctuation of zooplankton and that of the fishery. It will be admitted that the fluctuation of zooplankton need not necessarily entail

a diametrically opposite fluctuation of phytoplankton, but we shall not here attempt to discuss the causes which promote paucity or abundance of phytoplankton.

But little is known at present of the food of Copepods, and the inversion of the phytoplankton curve in comparison with that of zooplankton cannot be offered in any way as evidence that Diatoms, Peridiniales, and other comparatively large protophyta taken in tow-nettings are the food of Copepods. Therefore the paucity of phytoplankton correlating to a large extent with the abundance of mackerel (Fig. 2) need not at present be considered as other than additional evidence to show that where zooplankton is in excess of phytoplankton mackerel are more numerous—the subject of a former paragraph.

Briefly now to summarize the results of the present investigations. The following considerations are submitted as forming the principal points of correlation between the plankton and mackerel during 1906 and 1907.

(i) That during the three months forming the more important part of the spring mackerel fishing in the west part of the English Channel and Bristol Channel, viz. April, May, and June, mackerel appear to feed for the greater part on plankton.

(ii) That the plankton organisms observed in the stomach contents of mackerel are also to be found in tow-nettings taken on the same position from whence the fish are derived. Further, that in a majority of cases, the relative quantities or proportions of such species are also common to both tow-nettings and stomach samples.

(iii) That in April of the two years under present consideration, where zooplankton was in excess of phytoplankton mackerel were more numerous.

(iv) That the abundance or paucity of zooplankton during a certain number of years (1903–7) appears to be correlated with the greater or less abundance of mackerel.

III. THE "START" MACKEREL FISHERY.

I. GENERAL CONDITIONS IN 1907.

From the reports of fishermen at Plymouth and Newlyn, together with information derived from a fish salesman agent at Boulogne, it appeared that from the end of December, 1906, and throughout January, February, and the greater part of March, a regular and profitable trawl fishery for mackerel was carried on in an area of 20 to 40 miles S.S.W. to S.E. of Start Point.

Cligny, in a paper entitled "Les prétendues migrations du maquereau," has pointed out that the existence of mackerel congregated in dense shoals on the bottom in this particular area, was first brought to light during the winter of 1901, and that since that time a regular trawling industry for mackerel by means of a specially designed trawl has been carried on by the Boulogne fishermen, in the early spring.

In regard to this fishery, it has been stated by many fishermen at Plymouth that the best catches are made during the daytime, night trawling being often entirely unproductive.

From a consideration of this fact, the fishermen at first were of the opinion that the mackerel rose to the surface at night, and a certain number of boats shot drift-nets in the area where it was known that successful trawling during the day had been carried out. In every instance, however, the catches made at the surface were very light, and the practice was soon abandoned owing to the risk of damage to nets.

Toward the end of March, 1907, a Plymouth steam trawler, the *Condor*, was furnished with a special mackerel trawl, constructed in France; but losing this net on her first shot on the mackerel ground, an ordinary otter trawl was employed, with the result that a catch of nearly eight thousand mackerel was made, fish measuring 12½ to 14 in. in length. A Boulogne fisherman, who was superintending this fishing, expressed an opinion that had the trawl been a regular mackerel trawl, and the speed capability of the vessel greater, a far larger catch would have been made. This fishing was carried out, on a position roughly 25 miles S.W. of Start, on the 24th of March. Five days later a Brixham smack landed nine mackerel caught amongst other fish 20 miles S.E. of Start. From information received from Boulogne* it would appear that in 1907, throughout January, February, and the earlier part of March, the French trawling fleet, numbering nearly thirty vessels, were landing regular catches of sixty thousand down. During the third week of March, however, the catches rapidly decreased, until at the end of the month scarcely ten per cent of the former catches were landed, and the fishery was therefore discontinued.

Cligny, in the paper mentioned above, remarks on the close shoaling within certain limited areas on the ground in question, and this condition has been further evidenced during 1907 by statements made by the Boulogne fisherman in charge of the *Condor's* operations, who mentioned that of two vessels trawling within half a mile of each other, on a parallel course, the one would often obtain a large catch, whilst

* A series of telegrams giving daily market reports, for the use of which the writer is indebted to Mr. R. H. Palmer.

the other would fish lightly. The same fisherman, moreover, stated that he considered the shoals to lie parallel with the shore line.

[*Note.*—Amongst the fishing community at Plymouth and Newlyn a considerable diversity of opinion at one time existed in regard to the form and construction of the mackerel trawl. It may, therefore, be desirable to state that the writer was informed by Mr. Chant, the owner of the *Condor*, that the following details of construction, present in the net which was lost, constitute the essential points in which the mackerel trawl differs from an ordinary otter trawl.

Not being in a position to show the actual specifications of the trawl in question, Mr. Chant stated that the otter boards were heavier; the length of the foot rope was 92 feet (less than that of an ordinary otter trawl, which is usually 120 to 130 feet), and that the cod end was longer and bred of a finer mesh, viz. one inch. These points alone, he explained, constituted the difference in construction. The main point of the successful manipulation of the trawl, he stated, appeared to lie in the fact that, when trawling is proceeding at the pace of three miles an hour, the length of hawser employed should be five times the depth of the water.

With this length of hawser, he explained, together with the extra weight of the otter boards, there is no chance of the trawl leaving the ground, although it does not work so heavily as an ordinary trawl would, at the usual pace of two miles an hour.

Mr. Chant further stated that the mackerel taken by the *Condor* were caught in an ordinary otter trawl, the cod end of which had been backed with netting of a finer mesh.]

II. THE PHYSICAL AND BIOLOGICAL CONDITIONS OBSERVED ON THE START MACKEREL GROUND.

As a result of a series of observations taken from the *Oithona* at two positions on the mackerel trawling ground on March 27th, 1907, the following is a summary of the chief physical and biological conditions then observed within the area:—

First Position.—15 miles S.W. from Start Point.

Depth, 38 fathoms.

Condition of bottom, fine sand.

Temperatures: surface, 9·25°.
11 fathoms, 8·35°.
22 fathoms, 8·26°.
Bottom, 38 fathoms, 8·3°.

Second Position.—21 miles S. × W. ¾ W. of Start.

Depth, 39 fathoms.

Condition of bottom, coarse sand, fine gravel.

Temperatures: surface, 9·45°.
16 fathoms, 8·65°.
Bottom, 39 fathoms, 8·65°.

General condition of plankton* taken by coarse and fine nets:—

Bottom (39 *fathoms*). Four species of Copepods, chiefly *Temora longicornis*, not abundant; few other metazoa, including *Oikopleura dioica*, rare.

Phytoplankton in excess of zooplankton, composed largely of diatoms, *Lauderia borealis* and *Chaetoceras densum*, both common.

Fourteen other species of diatoms observed.

Surface plankton, similar in every respect to the bottom samples but slighter in bulk.

Petersen trawl samples from surface, midwater and bottom were composed largely of several species of amphipods: *Aphereusa bispinosa*, very abundant, *Bathyporeia pelagica*, rare, *Euthemisto gracillipes*, rare, *Monoculodes sp.*, rare, *Paratylus vedlomensis*, rare, *Stenothoë marina*, rare, *Urothoe elegans*, rare, etc. Schizopods, viz. *Anchialus agilis*, rare, *Gastrosaccus spinifer*, rare, *Mysidopsis angusta*, rare, and *M. gibbosa*, very rare. A fair number of post-larval fish were also taken, including *Clupea harengus*, plentiful, *Pleuronectes microcephalus*, common, *Solea variegata*, rare, etc.

An unsuccessful attempt was made to obtain mackerel in the otter trawl. The following species, however, were taken after a two hours' haul: *Arnoglossus laterna* and *A. megastoma*, *Callionymus lyra*, *Gadus minutus*, *G. luscus*, and *G. merlangus*, *Gobius quadrimaculatus*, *Pleuronectes platessa*, *Raia blanda*, *Rhombus laevis*, *Solea variegata*, and *S. lascaris*, *Trachinus draco*, *Trigla cuculus*, *T. gurnardus*, *T. hirundo*, and *T. lineata*, *Zeus faber*, together with several invertebrates.

III. GENERAL CONDITIONS OBSERVED IN STOMACHS OF MACKEREL TRAWLED ON THE START GROUND.

The contents of six stomachs were examined from the fish taken by the *Condor* on March 24th, 1907. A general determination based upon the six samples will be found in the Food and Plankton Tables (Table V), Sample No. 24. It is desirable, however, to describe the present material more particularly. In the six samples there appeared to be two distinct types of food, together with intermediate stages, in

* See Plankton Tables, Sample No. 38.

which the one converged into the other, forming, so to speak, a mixed sample. In one stomach only there occurred a pure zooplankton sample, consisting almost entirely of *Temora longicornis*; three other species of Copepods were observed in extreme scarcity, viz. *Centropages typicus*, *Paracalanus parvus*, *Pseudocalanus elongatus*, together with a few Caridid larvæ and Amphipod remains. This sample alone constituted the one extreme; the other, which may be considered as phytoplankton, was represented by three slight samples, which were composed mainly of a number of plankton diatoms (*Lauderia borealis* and *Chaetoceras densum* principally), together with a few bottom forms such as *Rhabdonema sp.*, forming with an indeterminable quantity of *Phæocystis globosa* a glutinous mass. Entangled in this material were observed also a few *Temora longicornis* and the three other species of Copepods above mentioned, together with a large number of *Oikopleura dioica*.

In the case of the two mixed samples, two slightly different types of food were observed. In the one *Temora longicornis* occurred fairly plentifully throughout the stomach contents, which otherwise were composed of the phytoplankton mass, as already described. In the second instance *Temora longicornis* formed an almost pure sample in a layer deposited above the phytoplankton. In connection with *Oikopleura dioica* it is interesting to note the following points. It occurred in greater abundance in the stomach samples showing phytoplankton and mixed material than it did in the tow-nettings taken from the *Oithona* (see Table No. II, Sample No. 38). Secondly, it was not observed at all in the sample composed entirely of *Temora longicornis;* and lastly in the mixed sample already referred to, where *Temora* was deposited in a layer, it did not occur amongst the Copepod material, but was plentiful in the lower layer of phytoplankton. These points alone in connection with *Oikopleura dioica* appear to constitute the sole difference existing between the plankton samples and stomach material.

CONCLUSION.

It has been suggested by several previous authors* that the migrations of the mackerel are not so extensive as hitherto generally supposed. Cligny, in the paper already referred to, states that, as far as his observations extend, mackerel return year after year, at the close of the shoaling season, to certain confined areas not far

* Allen, "Report on the Present State of Knowledge of the Habits and Migrations of Mackerel" (*Scomber scomber*), p. 26, *M.B.A. Journal*, vol. v. (N.S.).

Garstang, "On the Variation Races and Migrations of the Mackerel" (*Scomber scomber*), p. 286, *ibid.*

Cligny, *Les prétendues migrations du Maquereau.*

removed from the spawning grounds. At present only a few of these winter quarters are known to fishermen. Unless, therefore, certain other areas in the Channel exhibiting physical features common to the Start ground were thoroughly investigated, any attempt to suggest a reason for the preference of the fish for such particular spots would be based upon insufficient evidence.

In reviewing the foregoing observations upon the physical and biological conditions of the Start ground toward the close of the trawling season, it is desirable to draw attention to the following points: (1) that these bottom shoaling fish appeared to be feeding largely upon plankton; (2) that the plankton species observed in the stomach contents were common to the tow-nettings taken within the fishing area; (3) that *Oikopleura dioica* occurred in great abundance in stomach contents composed largely of phytoplankton, but in those containing a considerable quantity of zooplankton it was scarce, and further that, under the former circumstance, it was far more plentiful than in the tow-nettings taken within the fishing area; (4) that the tow-nettings taken on the bottom showed a greater bulk of material than those from the surface.

IV. FISHERMEN'S "SIGNS."

Amongst the west and east country fishermen there are generally recognized certain distinctive types of water in which mackerel are said to occur more or less abundantly. According to the men's statements, the colour and appearance of the water, its smell, and possibly upon occasion the presence of certain marine birds, comprise the only indications by which the drifter is guided in making choice of his position.

That these "signs," as they are termed, are the outcome of experience there can be no question, and the greater or less capability for interpreting them makes a better or worse fisherman. An instance occurred on one occasion when I was at Mevagissey, when one fisherman shot his nets a few miles to the landward of the rest of the pilchard fleet and secured a top catch; when questioned as to his reasons for doing so he explained that the signs at that particular position were altogether better than any that he had seen the previous night farther out. At other times I have heard a fisherman state that he could not hope for even a fair catch, as the class of water was entirely unsuitable, and on hauling nets this surmise has been found correct in every instance.

Before proceeding to treat the matter in detail it will be well to

summarize the result of systematic inquiry made amongst the fishermen in regard to their views upon the subject, and to detail the different characteristics of the various types of water as described by the fishermen themselves.

"*Stinking Water*" is of a dull leaden colour even in bright sunlight, so dense that a man looking over the side of a sailing drifter cannot see down to the keel. It possesses, according to the fishermen, a distinctly noxious smell, which has been described as similar to that of decaying seaweed. The men are agreed that mackerel are not to be found in such water; but one informant stated that scad or horse mackerel are often present in fair-sized shoals.

"*Grey Water*" is somewhat similar to the foregoing, but does not possess an unpleasant smell. Mackerel are never numerous in such water.

"*Blue*" and "*Green Water*" are both suitable for good shoals of fish. They differ, according to the fishermen, merely as regards colour. Both are so clear that the keel of the vessel can be seen distinctly. Both varieties are the usual types of water found in the western area in the early part of the season, right up to the first or second week in May. The fishermen are agreed in considering either type sufficiently promising to allow of fishing with some prospect of a fair catch.

"*Yellow Water*" is considered to be the best of any. This, according to the statement of many fishermen, exhibits the following characteristics. It seldom appears before the beginning of April, and more often not until the last week of that month. It is of a distinctly yellow tint, and rather dense when viewed either in sunlight or under a dull sky; often it appears in patches of greater or less extent. In certain years the sea west of Scilly has been almost entirely of this type of water. It appears, according to certain statements, to be teeming with "minute animal life." The fishermen agree in stating that the largest catches are always made in such water, and that it is not usual for an unproductive shot to be made, although, by the statement of several fishermen interrogated upon the point, it would appear that *light* catches are occasionally made in the best type of yellow water. Certain fishermen consider that the colour of the water is not due to the excreta of mackerel, but to the general colour of the "swarms of water fleas," whilst others on account of its density contend that it is coloured by excrement of mackerel.

Other "signs."—Apart from the characteristic of smell invariably associated with so-called 'stinking water," the generality of fishermen are agreed that a shoal of drift fish may be detected by their smell. This is more strongly pronounced in the case of pilchards, but, with

mackerel shoaling densely, the fishermen state that there is no mistaking it. An oily appearance at the surface of the water generally occurring in "splats," i.e. patches, is also said to be a sure indication of drift fish.

A milky appearance of the surface generally occurring in inshore waters, where there is no addition of china clay to the water, is associated by the fishermen with shoals of small mackerel, the milky appearance being due, it is stated, to excrement.

"Signs" of shoaling fish offered by the presence of sea-birds preying upon them occur more frequently, according to the fishermen's statement, in inshore waters, and the point is one which has already been described by previous writers, and need not therefore be discussed here.

COMPARISON OF "SIGNS" OFFERED BY DIFFERENT TYPES OF WATER WITH THE CONDITION OF PLANKTON OCCURRING IN SUCH WATER.

In order to endeavour to ascertain to what extent these colour "signs" are produced by plankton conditions, a number of plankton samples were taken for me in 1906–7 by fishermen, and labelled with reference to the particular type of water from which they were derived.

"*Stinking Water.*"—Sample No. 39, Plankton Tables, was taken by myself on April 10th, 1907, in an area of water termed by the fishermen "stinking," which, it was stated, extended from the Lizard to Land's End in a zone of varying width about ten miles or more from the shore. At the particular position at which it was taken, 6 miles N.W. × W. of Lizard, the fishermen were agreed in stating that the water was a fair sample of the "stinking" type, and that it would be useless to shoot in it. The colour and characteristics generally were in accordance with the description already given; but although the fishermen were agreed in saying that there was an obnoxious smell, I was unable myself to detect it. The analysis of the sample showed (by the method of comparison described in a former section) a moderate preponderance of phytoplankton over zooplankton, but the total bulk of the sample was comparatively small. As will be seen on reference to the Plankton Tables, the phytoplankton was mainly composed of diatoms, of which *Chaetoceras boreale* and *C. densum* were both common. *Phaeocystis globosa* appeared to be rare. The zooplankton comprised three Copepods, *Acartia clausi*, *Oithona similis*, and *Pseudocalanus elongatus*, moderately common. *Calanus finmarchicus* was rare.

"*Green Water.*"—It will be convenient at this point to compare the foregoing with another sample (No. 40, Plankton Tables) taken on the same date outside the "stinking water." This was at a position 16 miles

S.W. of Lizard, where a catch of 500 mackerel was made. The water appeared to be of a distinctly different type of a clear green tint. This was considered by the fishermen to be in every way suitable for the presence of shoaling fish. The examination of the sample showed the following points. Zooplankton was in excess of phytoplankton. This condition, however, was not brought about by a very pronounced decrease in the quantity of diatoms, but by the increased number of Copepods. *Calanus finmarchicus*, which was rare in the former sample, was common in the present one.

Between Samples 24 and 26, Plankton Tables, the former of which was taken by fishermen in "green water" and the latter in "blue," and from widely dissimilar positions, viz. 35 miles S.S.W. of Newlyn and 18 miles south of the Lizard, on May 5th and 10th respectively, there did not appear to be any striking points of difference. In each zooplankton was in excess of phytoplankton. The relative quantity of phytoplankton of the "green water" sample, however, was greater than that of the "blue water," although in the latter there was a slight quantity of *Phaeocystis globosa*, which was absent from the former. A greater variety of diatoms was observed in the "blue water" sample than in the "green," the higher proportion in the latter, already referred to, being due to two species, *Rhizosolenia alata* and *R. styliformis*, both plentiful.

In the main the zooplankton observed in each sample was similar. The Copepod *Temora longicornis*, however, occurred in the "blue water" sample, whilst it was absent from the "green"; but the more eastern distribution of the species described under a former heading would probably account for its absence in this sample of more western origin.

Samples 32 and 33, Plankton Tables, may be compared in a similar manner. They are taken later in the season, but present no striking dissimilarity.

No verified observations were taken in "grey water" except Sample 23, which, as stated in a footnote, would appear to be unreliable.

"*Yellow Water*."—In 1906, on May 20th, a sample was taken by fishermen in such water 40 miles S.W. of the Bishop. Unfortunately, however, the bottle containing the sample was broken in transit, and in consequence the exact nature of the plankton was difficult to determine. It appeared, however, to be composed very largely of the two Copepods *Calanus finmarchicus* and *Pseudocalanus elongatus*, and from the appearance of the remains it seemed to have been a very bulky sample.

This sample formed the sole observation from "yellow water" furnished by fishermen during 1906 and 1907. Throughout May, 1907,

however, when the sea west of Scilly was, according to the fishermen's statement, teeming with mackerel, "yellow water" was commonly met with on the fishing grounds. An examination of the Samples 50 to 57 (Plankton Table No. II), all of which were taken either adjacent to or on the fishing area during the international plankton cruise May, 1907, will serve to show that throughout the area covered the samples taken showed a certain similarity. Phytoplankton was entirely absent and the zooplankton was confined almost entirely to three or four principal forms, of which *Calanus finmarchicus* and *Pseudocalanus elongatus* were the most important.

At one station, 49° 49′ N. × 6° 59′ W. (Sample No. 52), the sea was considered to be of a decidedly yellow tint, according to the statement of Mr. D. J. Matthews, the leader of the expedition, and an analysis of the very bulky sample showed that it was composed almost entirely of the two species mentioned above, in almost equal abundance.

The possible inferences which may be drawn, therefore, from the consideration of the foregoing observations can be briefly summed up as follows:—

That in the "stinking water" sample, phytoplankton was in excess of zooplankton, but that there was no evidence to show from whence colour or smell were derived, beyond evidence of a negative character, which would tend to suggest that the smell did not arise from the condition of plankton. This suggestion is based upon the fact of an almost equal quantity of phytoplankton occurring in the case of the "green water" sample formerly referred to, "green water," according to the fishermen's statement, being invariably free from smell. The evidence offered by the analyses of "blue" and "green water" samples would suggest that the plankton taken in such water was of a type comprising a fair number of species in which, in the present examples, zooplankton was in excess of phytoplankton. From lack of observations, however, it cannot be suggested that this is always the case.

Finally, with regard to "yellow water," the somewhat conflicting opinions expressed by fishermen as to the causes which give rise to the colour, already explained, would suggest that the yellow tint is accounted for either by the presence of excrement arising from densely shoaling fish or from the presence in large numbers of certain Copepods. In view of the fact that several fishermen declare that light catches of mackerel may be taken in "yellow water," and the evidence offered by the analyses of certain plankton samples, it would appear to be more probable that the coloration arose from the latter cause. Were this view adopted, moreover, it would be strictly in accordance with the theory already discussed, of mackerel being abundant where food is plentiful.

Table No. I.—Plankton collected on Mackerel Grounds, 1906.

Note.—An asterisk thus * signifies sample collected by G. E. Bullen.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Month	Feb.						Mar.		April														May									June					
Day	1	12	12	13	14	24	12	24	10	21	23	23	23	23	23	24	24	24	24	24	26	26	1	5	10	10	15	18	19	19	23	5	7	8	13	17	23
Locality	3 m. W. of Eddystone	Sevenstones	8 m. S. of Newlyn	6 m. S.E. of Mousehole	9 m. S.S.W. of Mousehole	Sevenstones	Sevenstones	Sevenstones	Sevenstones	20 m. S. of Wolf	6 m. S.W. of Looe	7 m. S.W. of Dodman	2 m. S.W. × S. of Lizard	15 m. S.W. × S. of Lizard	30 m. S.W. × S. ½ S. of Lizard	30 m. S.W. of Wolf	14 m. S.W. × W. of Wolf	10 m. N.W. ½ N. of Longships	5 m. S.S.W. ½ W. of Mousehole Point	8 m. E. ½ S. of Lizard	Sevenstones	35 m. N. of Longships	12 m. S.S.W. of Wolf †	35 m. S.S.W. of Newlyn	Sevenstones	18 m. S. of Lizard	Stat. E. 5	50° 47′ N. × 6° 36′ W.	Stat. E. 6	Stat. E. 7	Sevenstones	70 m. W.S.W. of Wolf	60 m. S.W. × W. of Scilly	Sevenstones	25 m. W. × S. of Bishop	60 m. S.W. × W. of Bishop	Sevenstones
	*		*	*	*					*	*	*	*	*	*	*	*	*	*	*																	
Diatomaceae. Sample No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Actinoptychus undulatus, Ehbg.	r	r	r	+	r	r	r	+.	r	r	–	–	–	–	–	r	–	–	–	–	r	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Asterionella japonica, Castr.	r	r r	r	r	+	+	r	r	r r	–	–	r r	+	+	–	–	–	+	+	r	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Bacillaria paradoxa, Gmel.	–	r r	r	+	r	r r	r	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Biddulphia alternans, V. Heurck	–	r r	r r	–	r r	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
mobiliensis, Bail.	c	r	+	c	c	+	+	+	+	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	r r	–	–	–	–	r	–	–	r r	–	–	–
Cerataulina Bergonii, Perag.	–	–	–	–	–	–	–	–	–	c	–	–	–	–	+	+	+	–	+	–	r	–	r	–	+	–	–	r r	–	–	+	–	–	r r	–	–	–
Chaetoceras boreale, Bail.	–	–	r r	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r r	r	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–
contortum, Schütt	r r	–	–	–	r	–	–	r r	–	–	c	c	r r	r r	–	r r	–	r	c	c	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
convolutum, Castr.	–	–	–	–	–	r r	r r	–	r r	–	–	–	–	–	–	–	–	–	–	–	r r	–	–	–	r r	–	r r	–	–	–	r	–	–	–	–	–	–
danicum, Cleve	+	r r	r	r	+	c	r	r r	+	r r	r	r r	r r	r	r	r r	r r	+	r r	r	+	r	–	–	–	–	–	–	–	–	–	–	–	–	r r	r r	–
debile, Cleve	+	–	r	–	r	–	r r	–	r r	–	–	+	r	+	r	–	r	+	+	+	+	r r	–	r	r r	–	–	–	–	–	r	–	–	r	–	–	–
decipiens, Cleve	r r	–	–	r r	+	r r	r r	–	+	–	+	+	+	r	r	r	r	+	+	+	r	r	–	–	–	–	r r	–	–	–	–	–	–	r r	–	–	–
densum, Cleve	r	–	–	–	–	r r	r r	–	r	–	+	+	+	+	r r	–	–	r	+	r	+	+	r r	r	+	r r	–	+	+	r r	r	–	–	r	r r	–	r r
lasciniosum, Schütt	–	–	–	r r	r r	–	–	–	–	–	–	–	–	r r	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r r	–	–	–
Schütti, Cleve	–	–	–	–	r r	r	r r	–	r r	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	r r	–	–	–	–	–	–	r r	–	–	r r	–	r r	–
teres, Cleve	–	–	–	–	–	r r	r r	–	–	–	–	–	–	–	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Corethron hystrix, Hensen	r	r r	r	r	+	r	r	r r	r r	–	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	r r	–	–	–	–	r	r r	–	–	–	–
Coscinodiscus concinnus, W. Sm.	–	r	r r	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r r	–	–
Grani, Gough	r	–	–	–	–	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
excentricus, Ehbg.	+	c	+	+	+	+	+	+	+	r r	r r	r r	r r	–	–	r r	–	–	–	r r	r	–	–	–	r r	r	–	–	–	–	–	r	–	–	r	r	–
radiatus, Ehbg.	+	r	+	+	+	r	r	r	c	r r	r	r	r	r	r	+	r	r	r	–	r	–	r r	–	–	r r	r	r r	–	+	–	r r	–	–	r	r r	–
Ditylum Brightwelli, West	+	–	–	–	r r	r	+	r	+	–	r r	–	r r	–	–	–	–	r r	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Eucampia zodiacus, Ehbg.	–	–	–	r r	–	–	–	–	–	–	+	+	+	c	r r	–	+	+	+	c	r	+	–	–	r	–	–	r	+	–	r	–	–	+	–	–	r
Fragillaria oceanica, Gran.	–	–	r r	r r	r r	r r	–	–	–	–	–	–	–	r	+	+	r r	+	–	–	r	–	r r	–	–	–	–	–	–	–	–	–	–	+	–	–	–
Guinardia flaccida, Perag.	–	–	–	–	r r	–	r r	–	–	+	c	c	c	c	+	r	+	c	c	c	+	c	+	r	+	+	r r	r	c	–	+	–	–	+	–	–	r
Hyalodiscus stelliger, Bail	r r	+	+	+	+	c	+	+	+	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	r	r r	r r	–	–	–	–	–	–	r	–	–	r r
Lauderia borealis, Gran.	+	–	–	r r	r r	r	r	r	r r	+	r	–	r	c	c	c	c	+	r	+	+	+	c	r r	r r	c	–	r	+	c c	+	r r	–	+	r r	–	–
Leptocylindrus danicus, Cleve	–	–	r r	r r	r r	–	–	–	–	r	–	r	r	r r	–	–	r	r	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Navicula, sp.	–	r r	–	–	r r	r r	r r	r r	r r	r	r r	r r	–	r r	r	r	+	r	r r	r r	–	–	r	r	–	r	–	r	r	c	r	–	–	–	–	–	r r

Nitzschia seriata, Cleve	–	–	r	r r	r	–	–	–	r r	–	–	r	–	r	–	–	–	–	c	–	–	–	–	c	–	–	–	–	–	–	–	–	–	–	–	–	–
Nitzschia, sp.	+	–	–	–	–	–	–	–	–	c	c	c	c	+	r	r	c	c	r	c	c	c	–	–	r r	–	–	–	r r	–	r	–	–	–	–	–	–
Paralia sulcata, Cleve	+	+	+	+	+	+	+	+	r	r	r r	–	r	+	r	r	–	–	–	–	r	–	r	–	–	r	r r	r r	–	r	–	–	–	r r	–	–	–
Pleurosigma, sp.	r	r r	r r	r	+	r r	r r	–	r r	–	–	r	r	–	r r	r r	r r	–	–	r r	–	–	–	–	–	–	r r	r r	r	r	–	–	–	r r	–	–	–
Rhizosolenia alata, Brtw.	r	r r	+	c	+	r r	–	r r	r	c	c	+	r	+	c	+	+	r	+	c	+	c	c	c	r	+	c	c	+	c c	r	r	r r	r	c	r	r
delicatula, Cleve	–	–	–	–	–	–	r r	r	–	r	+	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r r	–	–	–
semispina, Hens.	–	r r	+	r	+	r r	r	r	+	c	+	+	+	c	+	+	+	+	c	c	+	+	r r	r r	+	+	+	+	c	c c	+	–	r	+	c	r r	–
setigera, Brtw.	r r	–	–	r	r	r	r	r r	+	+	r	r	r r	r	+	r	r	r r	–	r r	r r	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
shrubsolei, Cleve	–	–	+	+	r	–	–	–	r	–	–	–	r r	+	+	r	+	+	+	+	+	+	+	+	r	r	–	r	r r	r	r	r r	r r	r	c	–	r r
Stolterfothi, Perag.	–	–	–	–	–	–	–	–	–	–	c	+	+	+	+	r	+	c	c	c	+	+	r	–	+	–	–	+	c c	r r	+	–	–	c	r	–	+
styliformis, Brtw.	–	–	–	–	–	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	c	c	–	+	+	r	r r	c	r r	–	–	+	–	–	r r
hebetata, Hens.	–	–	–	–	–	–	r r	–	–	r	r	–	–	–	–	–	–	–	–	–	r	–	r	–	–	–	r	–	–	–	–	–	–	r	r r	–	r
Skeletonema costatum, Cleve.	+	–	–	r r	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Streptotheca thamesis, Cleve	r r	–	+	r	+	+	r	r	c	r	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thalassiosira decipiens, (Grun.)	–	r	–	r r	–	r	r	r r	–	–	–	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
gravida, Cleve	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nordenskiöldii, Cleve	–	–	–	r r	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thalassiothrix nitzschioides, Grun.	+	+	r	r	+	r r	+	+	+	–	r r	–	–	r	–	r r	–	–	–	–	r	–	–	–	–	–	r r	r r	–	r r	–	r r	–	–	r r	–	–
Peridiniales.																																					
Ceratium furca, Clap. and Lach.	–	–	–	–	–	–	–	–	r	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
fusus, Ehbg.	c	–	r r	r	r r	–	–	r r	+	+	c	c	+	+	r	r	+	r	+	+	r	r	r	–	–	r	r r	r r	r	–	r r	r r	–	r	–	r r	r r
horridum, Cleve	–	–	–	–	–	–	–	–	–	–	r r	r	+	+	r	–	r	–	r	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
longipes, Bail.	+	–	–	–	–	–	r r	r r	r r	r	+	+	+	+	r r	–	+	r r	+	+	r	–	r	r r	r r	–	–	–	r r	r r	r	–	–	r	–	–	r
tripos, O. F. Mull.	c	–	–	–	–	–	–	r r	r r	r	+	+	r	r	–	r	r r	–	r	+	r	r	–	–	–	–	r r	–	–	r	–	r	–	r r	r r	r	r r
Dinophysis acuta, Ehbg.	–	–	–	–	–	–	–	–	r r	–	–	–	r r	–	–	r r	r r	–	–	r r	–	–	–	–	–	r r	–	–	–	–	–	–	–	r r	–	–	r r
acuminata, Clap. and Lach.	–	–	–	–	–	–	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r r	–	–	–	–	–	–	–
rotundata, Clap. and Lach.	+	–	–	–	–	–	–	–	–	r r	–	–	r r	–	–	–	–	–	–	r r	–	r	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Diplopsalis lenticula, Bergh.	–	–	–	–	r r	–	–	–	–	–	r r	–	r r	–	–	r r	–	–	–	r r	–	–	r r	–	–	–	–	–	–	–	r	–	–	–	–	–	r
Peridinium conicum, Gran.	r	–	–	r r	r r	r r	r r	–	r r	+	+	+	+	+	r	+	r	r r	r	r	r r	–	–	–	–	–	–	–	r	r r	–	r r	–	–	r	–	r r
depressum, Bail.	r	–	–	r r	–	–	–	–	–	–	+	c	c	+	–	r	+	+	+	+	r	r r	r	r r	–	–	r r	–	+	r	r r	–	–	+	–	–	+
ovatum, Pouchet	–	–	–	–	–	–	r r	–	+	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	r r	–	–	–	–	r	+	r r	–	–	r r	–	–	r
pallidum, Östf.	r	–	–	–	–	–	–	–	+	r r	r	+	+	r	–	r	+	r	+	+	r	r	–	–	–	–	r r	–	r r	c	–	r r	–	–	r	–	–
Steini, Jörg.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r r	–	–	–	–	–	–	–	r r
Prorocentrum micans, Ehbg.	r	–	–	–	r r	–	–	–	r r	r r	–	r	r	–	–	–	–	–	–	r r	–	r r	–	–	–	–	–	–	r r	–	–	–	–	–	–	–	–
Protophyta cetera.																																					
Dictyocha fibula, Ehbg.	r r	–	–	r	r r	r r	r r	–	r	–	–	r r	–	r r	–	–	r r	–	r r	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Distephanus speculum, Ehbg.	–	–	–	r r	r r	–	–	–	–	–	–	–	–	r r	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Halosphaera viridis, Schmitz	–	r	+	+	+	r	+	+	+	+	r	+	r	r r	r	+	c	+	r	r	+	+	–	+	+	+	r	r	r	r	r	r r	r	r r	r	–	–
Phaeocystis globosa, Scheffel	r r	–	–	–	–	–	–	–	?	c	c c	c c	c c	+	r	r	c	c c	c	c c	c c	c c	–	–	–	+	–	–	–	–	+	r	–	–	–	–	–
Trochiscia Clevei, Lemm.	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Trichodesmium (?) contortum, Wille.	–	+	–	–	–	–	–	r	–	+	+	r	+	r	+	r	r	r	r	r	–	+	–	–	–	–	–	–	–	–	–	+	+	–	r	+	–

† An unreliable sample taken by fishermen.

TABLE No. I.—*Continued.*

NOTE—An asterisk thus * signifies sample collected by G. E. Bullen.

	Feb.						Mar.	
	1	12	12	13	14	24	12	24
	3 m. W. of Eddystone	Sevenstones	8 m. S. of Newlyn	6 m. S.E. of Mousehole	9 m. S.S.W. of Mousehole	Sevenstones	Sevenstones	Sevenstones
Protozoa. Sample No.	*1	2	*3	*4	*5	6	7	8
Tintinnopsis beroidea, Stein	+	r r	–	r	r	–	–	–
Noctiluca miliaris, Suriray	–	–	–	–	–	–	–	–
Caelenterata.								
Muggiaea atlantica, Cunn.	+	–	–	–	–	–	–	–
Pleurobrachia pileus, Fabr.	r r	–	–	–	–	–	–	–
Corymorpha nutans, Sars	–	–	–	–	–	–	–	–
Euchilota pilosella, Forbes	–	–	–	–	–	–	–	–
Euphysa aurata, Forbes	–	–	–	–	–	–	–	–
Hybocodon prolifer, Agassiz	–	–	–	–	–	–	–	–
Laodice calcarata, Agassiz	–	–	–	–	–	–	–	–
Margellium octopunctatum, Sars	–	–	–	–	–	–	–	–
Obelia nigra, E. T. Browne	–	–	–	–	–	–	–	–
Obelia sp.	–	–	–	–	–	–	–	–
Phialidum temporarium, E. T. Browne	–	–	r r	–	r r	–	–	–
Sarsia prolifera, M. Sars	–	–	–	–	–	–	–	–
Arachnactes Bournei, Fowler	–	–	–	–	–	–	–	r r
Echinodermata.								
Auricularia	–	–	–	–	–	–	–	–
Bipinnaria	–	–	–	–	–	–	–	–
Echinopluteus	r r	–	–	–	–	–	–	–
Ophiopluteus	r	–	–	–	–	–	–	r r
Vermes.								
Annelida larvae	r r	–	r	r r	r r	–	r r	r r
Sagitta bipunctata, Quoy and Gaim.	+	c	c	+	+	c	+	+
Tomopteris helgolandica, Greef	–	–	r r	r	r r	–	–	–

	April													
	10	21	23	23	23	23	23	24	24	24	24	24	26	26
	Sevenstones	20 m. S. of Wolf	6 m. S. of Looe	7 m. S.W. of Dodman	2 m. S.W.×S. of Lizard	15 m. S.W.×S. of Lizard	30 m. S.W.×S.½S. of Lizard	30 m. S.W. of Wolf	14 m. S.W.×W. of Wolf	10 m. N.W.½N. of Longships	5 m. S.S.W.½W. of Mousehole Point	8 m. E.½S. of Lizard	Sevenstones	35 m. N. of Longships
Protozoa. Sample No.	9	*10	*11	*12	*13	*14	*15	*16	*17	*18	*19	*20	21	22
Tintinnopsis beroidea, Stein	r r	–	–	–	–	–	–	–	–	–	–	–	–	–
Noctiluca miliaris, Suriray	–	–	r	c	r	r	–	–	–	r r	r	+	–	–
Caelenterata.														
Muggiaea atlantica, Cunn.	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pleurobrachia pileus, Fabr.	–	–	r	–	+	r r	r	r	r	r r	+	r	–	–
Corymorpha nutans, Sars	–	–	–	r r	r	r r	r	r	r	r r	r	r	–	–
Euchilota pilosella, Forbes	–	–	–	–	–	–	–	r	–	–	–	–	–	–
Euphysa aurata, Forbes	–	–	–	–	r r	r	+	r	r	r r	r r	r r	r	–
Hybocodon prolifer, Agassiz	–	–	–	–	r r	–	r	r r	r	–	r	r r	–	–
Laodice calcarata, Agassiz	–	–	–	–	–	–	+	+	r	–	–	–	–	–
Margellium octopunctatum, Sars	–	–	–	–	–	–	–	r r	–	–	r r	–	r r	–
Obelia nigra, E. T. Browne	–	–	r	+	+	+	+	+	+	+	+	+	r	r
Obelia sp.	–	+	r	+	+	+	+	c	+	+	r	+	–	r r
Phialidum temporarium, E. T. Browne	–	+	r	+	+	+	+	+	+	+	+	+	r	r
Sarsia prolifera, M. Sars	–	–	r	+	r	r	r r	–	–	–	–	–	–	–
Arachnactes Bournei, Fowler	–	r	–	–	r r	–	–	–	r r	r r	r	r	r	r r
Echinodermata.														
Auricularia	r r	–	+	+	r	r r	–	–	–	–	r	+	–	–
Bipinnaria	–	–	r	r	–	r r	r	–	r r	–	r	r	–	–
Echinopluteus	–	–	r	+	–	r r	r	–	–	–	–	+	–	–
Ophiopluteus	–	–	r	+	r	r r	–	r	–	r	r	+	–	–
Vermes.														
Annelida larvae	r r	+	+	+	+	+	+	+	+	+	+	+	+	+
Sagitta bipunctata, Quoy and Gaim.	–	c	c	c	+	+	c	c	c	+	r	r	+	+
Tomopteris helgolandica, Greef	–	–	–	–	r r	–	–	–	–	–	–	–	–	–

	May									June					
	1	5	10	10	15	18	19	19	23	5	7	8	13	17	23
	12 m. S.S.W. of Wolf †	35 m. S.S.W. of Newlyn	Sevenstones	18 m. S. of Lizard	Stat. E. 5	50° 47′ N. × 6° 36′ W.	Stat. E. 6	Stat. E. 7	Sevenstones	70 m. W.S.W. of Wolf	60 m. S.W.×W. of Scilly	Sevenstones	25 m. W.×S. of Bishop	60 m. S.W.×W. of Bishop	Sevenstones
Protozoa. Sample No.	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Tintinnopsis beroidea, Stein	–	–	–	–	r r	r r	r r	r r	–	–	–	–	r r	–	–
Noctiluca miliaris, Suriray	–	–	–	–	–	–	r	–	–	–	–	r	–	–	r
Caelenterata.															
Muggiaea atlantica, Cunn.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pleurobrachia pileus, Fabr.	–	+	–	–	–	–	r r	–	r	–	–	r r	–	–	r r
Corymorpha nutans, Sars	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–
Euchilota pilosella, Forbes	–	–	–	–	r	–	r r	r r	–	–	–	–	r	–	–
Euphysa aurata, Forbes	–	r	r r	–	r r	r	–	–	r	r r	–	–	r r	r	–
Hybocodon prolifer, Agassiz	r	+	–	+	–	–	r r	–	–	–	–	–	–	–	–
Laodice calcarata, Agassiz	–	–	–	–	+	–	–	–	–	–	–	–	–	–	
Margellium octopunctatum, Sars	–	–	–	r	–	–	–	–	r r	–	–	–	–	–	r r
Obelia nigra, E. T. Browne	–	r	r	r	–	+	+	–	r	–	–	–	–	–	–
Obelia sp.	–	–	r r	–	–	r r	r r	r	–	–	–	–	–	–	–
Phialidum temporarium, E. T. Browne	–	–	r r	r	r	+	r	–	r r	–	–	–	–	–	–
Sarsia prolifera, M. Sars	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Arachnactes Bournei, Fowler	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–
Echinodermata.															
Auricularia	–	–	–	r	r r	–	–	r r	–	–	–	–	–	–	–
Bipinnaria	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Echinopluteus	–	–	–	–	–	–	–	–	r r	–	–	–	–	–	r
Ophiopluteus	–	r r	–	–	r r	–	r r	–	r r	–	–	–	–	–	+
Vermes.															
Annelida larvae	–	r r	r	r	r r	r r	r r	r	r	–	–	–	–	r r	–
Sagitta bipunctata, Quoy and Gaim.	r	+	+	+	c	c	+	c	+	+	r	r r	+	+	r
Tomopteris helgolandica, Greef	–	–	–	–	–	–	–	–	–	–	–	–	r r	–	–

Crustacea copepoda.																																					
Acartia Clausi, Giesb	r	–	–	rr	–	rr	rr	rr	+	+	+	c	c	c	c	c	c	+	c	+	+	+	r	+	rr	r	rr	rr	r	c	+	rr	rr	c	rr	rr	r
Anomalocera Pattersoni, R. Temp.	–	–	–	–	–	–	–	rr	rr	rr	–	–	–	rr	r	r	–	rr	–	–	r	–	r	rr	–	–	rr	–	–	–	–	–	rr	rr	–	rr	–
Calanus finmarchicus, Gunn	r	c	+	+	+	+	+	+	r	+	+	+	+	+	c	c	+	+	+	c	+	+	r	c	cc	c	c	c	+	+	+	cc	cc	+	cc	cc	c
Candacia pectinata, Brady	–	–	–	–	–	–	–	–	–	rr	r	rr	r	+	+	+	+	+	r	+	rr	rr	–	rr	–	rr	–	–	rr	r	–	rr	–	r	–	rr	rr
Centropages typicus, Kroyer	+	rr	–	–	rr	–	r	r	r	r	r	r	r	+	+	r	r	r	c	r	r	rr	–	r	rr	–	rr	rr	rr	r	r	r	–	c	+	–	+
Corycaeus anglicus, Lubb.	+	–	–	–	–	–	–	–	rr	rr	+	r	r	+	rr	–	rr	+	+	+	–	–	–	rr	–	–	–	–	rr	r	–	–	–	–	–	–	+
Euterpe acutifrons, Dana	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Isias clavipes, Boeck	–	–	–	–	–	–	–	–	–	–	rr	rr	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–
Metridia lucens, Boeck	–	–	rr	r	r	–	–	–	–	r	–	–	–	rr	+	c	c	c	+	r	+	+	–	r	r	rr	+	+	rr	–	rr	r	r	–	r	–	–
Microsetella atlantica, Brady	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–
Oithona nana, Giesb	–	–	–	–	–	–	–	–	–	rr	+	+	r	–	r	+	r	r	rr	rr	r	r	–	r	rr	r	–	–	–	–	rr	r	+	rr	+	–	r
plumifera, Baird	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
similis, Claus.	–	–	rr	r	rr	r	r	r	r	r	r	+	r	rr	rr	r	rr	–	–	r	r	rr	–	rr	r	rr	c	rr	rr	+	r	rr	r	r	r	rr	r
Paracalanus parvus, Claus.	+	rr	+	+	+	r	r	r	rr	+	+	+	+	+	+	+	+	+	r	+	+	+	–	+	+	r	+	+	rr	c	+	+	+	rr	+	+	+
Parapontella brevicornis, O. F. Mull.	–	–	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	–	–	–
Pseudocalanus elongatus, Boeck.	+	r	+	+	+	r	+	+	–	c	c	+	c	+	+	+	+	+	+	+	+	+	–	c	+	+	c	cc	+	c	+	c	cc	r	cc	c	+
Temora longicornis. O. F. Mull.	r	rr	–	–	–	–	–	–	–		+	r	+	r	r	–	rr	+	+	+	–	rr	–	–	–	+	–	rr	r	rr	+	–	–	r	–	–	–
Crustacea cetera.																																					
Anchialis agilis, G. O. Sars	–	–	–	–	rr	–	–	–	–	–	r	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–
Apherusa Clevei, G. O. Sars	–	–	–	rr	–	–	–	–	–	r	–	–	–	r	+	rr	r	–	–	–	–	–	–	r	–	r	–	–	–	rr	–	–	–	–	–	–	–
Carididae larvae	–	rr	–	rr	rr	r	–	–	–	r	–	–	+	+	c	c	+	+	rr	r	c	c	–	+	r	+	–	–	–	–	r	r	–	–	r	r	rr
Cirripedia larvae	–	–	–	rr	rr	–	–	rr	rr	+	r	r	r	rr	rr	r	rr	+	r	r	rr	rr	rr	–	–	–	–	–	rr	–	–	–	–	–	–	–	–
Euthemisto gracillipes, Norman	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	rr	rr	rr	–	–	–	rr	–	–	–	–	rr	–	–	–	rr	–
Evadne Nordmanni, Loven	–	–	–	–	rr	–	–	–	–	–	c	c	+	+	r	–	+	c	c	+	–	–	r	rr	–	+	–	–	rr	r	r	–	–	–	+	r	r
Nauplius	r	rr	r	r	+	+	+	+	r	c	c	+	–	rr	–	r	r	r	r	r	r	–	–	+	+	r	+	rr	r	+	+	+	+	+	+	+	r
Nictyphanes Couchii, Bell	–	–	–	–	–	–	rr	+	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–
Podon intermedius, Lilljeb.	–	–	–	–	–	–	–	–	–	–	+	+	+	+	rr	–	r	+	+	+	r	–	–	–	rr	r	–	–	–	rr	r	–	–	r	r	–	r
Zoeae	–	rr	–	rr	rr	r	r	r	–	r	r	r	+	+	+	c	+	+	r	+	+	+	–	+	+	c	r	+	+	+	r	r	–	–	–	rr	r
Megalopa stage	–	–	–	–	–	–	–	–	–	rr	–	–	–	rr	rr	r	–	–	–	–	rr	rr	rr	–	–	–	–	rr	rr	–	–	–	–	–	–	–	–
Mollusca.																																					
Clione limacina	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	rr	rr	–	–	–	–	–
Gasteropoda larvae	–	–	–	–	–	rr	rr	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	rr	–	–	rr	–	–	–
Lamellibranchiata larvae	+	–	+	r	r	rr	r	r	–	rr	–	–	–	–	r	–	r	–	–	–	rr	–	–	–	r	–	–	–	–	–	r	–	–	rr	–	r	–
Limacina retroversa, Flem.	–	r	r	+	+	r	–	–	–	r	–	r	r	r	+	r	rr	–	r	r	rr	rr	–	r	–	rr	rr	rr	rr	r	rr	r	cc	–	r	c	r
Tunicata.																																					
Oikopleura dioica, Fol.	c	–	+	+	+	rr	+	c	+	+	c	+	+	c	c	+	+	+	+	+	+	r	r	c	+	c	rr	r	r	r	+	r	–	r	rr	r	r
Vertebrata.																																					
Fish ova	–	–	c	r	+	rr	rr	r	+	r	r	r	r	r	+	r	r	r	rr	r	rr	r	rr	r	rr	+	rr	rr	rr	rr	r	+	+	+	+	r	–
larvae	–	–	+	rr	rr	–	–	rr	–	r	r	r	r	+	+	+	+	+	r	r	r	rr	rr	–	–	+	–	rr	–	rr	rr	–	–	rr	–	–	–

† An unreliable sample taken by fishermen.

TABLE No. II.—PLANKTON COLLECTED ON MACKEREL GROUNDS, 1907.

NOTE.—An asterisk thus * signifies sample collected by G. E. Bullen.

	March	April										May												June		
	26	10	10	16	16	16	16	16	17	17	17	9	16	16	17	17	17	17	17	18	21	29	31	4	6	14
	21 m. S.×W. $\frac{3}{4}$ W. of Start	6 m. N.W.×W. of Lizard	16 m. S.W. of Lizard	12 m. S. $\frac{3}{4}$ W. of Looe	17 m. S.×W. of Dodman Point	15 m. S. of the Lizard	$5\frac{1}{2}$ m. S.W. $\frac{1}{4}$ W. of Lizard	$1\frac{1}{2}$ m. S.×W. $\frac{3}{4}$ W. of Runnelstone	10 m. N. $\frac{3}{4}$ W. of Longships	20 m. N. of Longships	10 m. S.W. of Wolf	28 m. W.×S. of Bishop	Stat. E. 30	Stat. E. 6	49° 49' N.×6° 59' W.	49° 48' N.×7° 10' W.	Stat. E. 25	49° 24' N.×6° 36' W.	Stat. E. 5	Stat. E. 7	18 m. W.N.W. of Bishop	55 m. S.W. of Mousehole	60 m. W.S.W. of Wolf	30 m. W.S.W. of Bishop	50 m. S.W. of Wolf	55 m. S. of Newlyn
	*	*	*	*	*	*	*	*	*	*	*															
Diatomaceae. Sample No.	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
Asterionella japonica, Castr.	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Bacillaria paradoxa, Gmel.	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Biddulphia mobiliensis, Bail.	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cerataulina Bergonii, Perag.	–	r	r r	r r	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chaetoceras boreale, Bail.	–	c	+	+	+	+	+	+	r	r	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
contortum, Schütt	+	r	+	r	r r	r r	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
convolutum, Castr.	–	–	r r	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
danicum, Cleve	+	–	–	+	r	r	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
debile, Cleve	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
decipiens, Cleve	+	r	r	r	c	+	c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
densum, Cleve	c c	c	+	c	c	c	c	+	+	r	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	r r	–
Schütti, Cleve	r r	–	–	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
teres, Cleve	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Corethron hystrix, Hensen	r	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Coscinodiscus excentricus, Ehbg.	+	–	r	–	–	–	–	–	–	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–
Grani, Gough	–	–	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
oculus iridis, Ehbg.	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
radiatus, Ehbg.	+	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ditylum Brightwellii (West)	–	–	–	–	–	r r	r	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Eucampia zodiacus, Ehbg.	–	–	–	–	r r	–	–	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Guinardia flaccida (Castr.)	–	–	r r	–	–	r r	+	r r	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Hyalodiscus stelliger, Bail.	–	–	–	r r	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lauderia borealis, Gran.	c c	+	c	c	c	+	+	–	–	–	r	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–

Nitzschia seriata, Cleve	–	r	–	c c	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nitzschia sp.	+	r r	r r	r r	c	c	c	c	c	–	c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Paralia sulcata (Ehbg.)	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pleurosigma sp.	–	–	–	–	r r	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rhizosolenia alata, Btw.	–	+	+	r r	–	r r	r r	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
delicatula, Cleve	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
hebetata, Bail.	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
semispina, Hensen	–	+	r	–	r	r	r	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
setigera, Btw.	r	–	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Shrubsolei, Cleve	+	+	r	+	r	r	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Stoltefothii, Perag.	r	r	r	r r	r r	+	r	r	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Skeletonema costatum (Greve.)	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Streptotheca thamesis, Shrub.	–	–	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thalassiosira decipiens (Grun.)	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
gravida, Cleve	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nordenskiöldii, Cleve	–	–	r r	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thalassiothrix nitzschioides, Grun.	r r	r r	+	–	–	r r	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r r	–
Peridiniales.																										
Ceratium furca (Ehbg.)	–	r r	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
fusus (Ehbg.)	–	+	+	–	+	+	+	r r	r r	r r	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–
longipes (Bail.)	–	r	r	r	r	r	r	r r	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
tripos (O. F. Mull)	–	r	+	r	+	+	+	–	–	r r	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–
Dinophysis acuta (Ehbg.)	–	–	r r	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
rotundata (Clap and Lachm.)	–	–	r r	–	–	r r	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Vanhöffeni	–	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Diplopsalis lenticula, Bergh.	–	–	–	–	r	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Gonyaulax polygramma, Stein.	–	–	–	–	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Peridinium conicum, Gran.	–	+	+	–	r r	+	+	+	r	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
depressum, Bail.	–	r	r	r	+	+	+	+	+	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
ovatum, Pouchet.	–	–	–	–	r r	r	r	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
pallidum, Ostf.	–	r	r	–	–	r	+	+	r	–	+	–	–	–	–	–	–	–	–	r r	–	–	–	–	–	–
Steini, Jörg.	–	–	r r	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Prorocentrum micans, Ehbg.	–	r	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Protophyta cetera.																										
Dictyocha fibula, Ehbg.	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Distephanus speculum (Ehbg.)	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Halosphaera viridis, Schmitz.	–	–	–	r r	–	–	r	r	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Phaeocystis globosa, Scherffel.	+	r	r	c c	c c	c c	c c	c	c	c	c c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Table No. II.—*continued.*

Note.—An asterisk thus * signifies sample collected by G. E. Bullen.

	March	April										May												June		
	26	10	10	16	16	16	16	16	17	17	17	9	16	16	17	17	17	17	17	18	21	29	31	4	6	14
	21 m. S.×W. ¾ W. of Start	6 m. N.W.×W. of Lizard	16 m. S.W. of Lizard	12 m. S. ½ W. of Looe	17 m. S.×W. of Dodman	15 m. S. of Lizard	5½ m. S.W. ¼ W. of Lizard	1½ m.S.×W.½ W. of Runnelstone	10 m. N. ¾ W. of Longships	20 m. N. of Longships	10 m. S.W. of Wolf	28 m. W.×S. of Bishop	Stat. E. 30	Stat. E. 6	49° 49′ N.×6° 59′ W.	49° 48′ N.×7° 10′ W.	Stat. E. 25	49° 24′ N.×6° 36′ W.	Stst. E. 5	Stat. E. 7	18 m. W.N.W. of Bishop	55 m. S. of Mousehole	60 m. W.S.W. of Wolf	30 m. W.S.W. of Bishop	50 m. S.W. of Wolf	55 m. S. of Newlyn
	*	*	*	*	*	*	*	*	*	*	*															
Protozoa. Sample No.	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
Noctiluca miliaris, Suriray	–	–	–	r r	r	r r	r	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tintinnopsis beroidea, Stein	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Caelenterata.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Arachnactis Bournei, Fowler	–	–	–	–	–	r r	–	r r	r r	–	r r	–	–	–	–	–	–	–	–	–	r r	–	–	–	–	–
Beroe ovata (Esch.)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r r	–	–	–	–	–	–	–	–
Corymorpha nutans, M. Sars.	–	–	–	–	–	–	–	–	r r	–	–	r r	–	–	–	–	–	–	–	–	–	r r	–	–	r r	–
Euchilota pilosella, Forbes	–	–	–	–	–	r r	–	–	–	–	–	–	r r	–	–	–	–	r	–	–	–	–	–	–	r r	–
Euphysa aurata, Forbes	–	–	–	r	–	–	–	–	–	–	–	r r	r	–	–	–	–	–	–	–	–	–	–	–	–	–
Dipurena halterata, Forbes	–	–	–	–	–	–	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Hybocodon prolifer, Agass.	–	–	–	–	–	–	–	–	r	r	r	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Laodice calcarata, Agass.	–	–	–	–	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Margellium octopunctatum, Sars.	–	–	–	r	r	r	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Margelis sp.	–	–	–	–	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Obelia nigra, E. T. Browne	–	–	–	r	r r	r r	r r	r	r	r	–	–	–	r r	–	–	–	–	–	–	r	–	–	–	–	–
Obelia, sp.	–	–	–	r r	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	r r	–	–	–	–	–
Phialidium cymbaloideum, Van Bened.	–	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
temporarium, E. T. Browne	–	–	–	r	r r	r r	r r	r r	r r	–	r	r r	–	r r	–	–	–	–	–	–	–	–	–	–	r r	–
Pleurobrachia pileus, Flem.	–	–	–	r r	–	–	r r	–	r r	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Sarsia prolifera, Forbes	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r r	–	–	r r	–

Vermes.																									
Annelida larvae	rr	–	–	+	r	r	r	r	r	r	r	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–
Sagitta bipunctata Quoy. and Gaim.	r	–	r	+	+	rr	–	r	+	+	+	r	+	+	–	–	+	+	+	+	r	+	r	+	+	+
Tomopteris helgolandica, Greeff.	–	–	–	rr	–	–	–	r	–	rr	rr	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–
Crustacea. Copepoda.																									
Acartia Clausi, Giesbr.	–	+	+	+	c	c	+	+	r	+	+	r	+	c	r	c	r	+	+	+	c	rr	–	rr	rr	r
Anomalocera Pattersoni, Templt.	rr	–	–	–	rr	rr	–	–	–	r	–	rr	rr	-	–	–	–	–	–	r	rr	rr	–	–	+	r
Calanus finmarchicus, Gunn	r	rr	c	+	r	c	rr	cc	c	c	cc	cc	cc	+	cc	cc	cc	+	cc	c	c	cc	cc	cc	cc	c
Candace pectinata, Brady	–	–	–	–	–	rr	–	rr	rr	rr	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Centropages typicus, Kröyer	+	r	–	+	+	r	r	rr	r	r	r	rr	r	+	–	r	–	r	r	c	r	rr	rr	rr	-	–
Corycaeus anglicus, Lubb.	–	–	–	–	r	+	r	–	+	rr	r	r	–	rr	–	–	–	–	–	–	–	–	–	–	–	–
Euterpe acutifrons (Dana)	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Isias clavipes, Boeck.	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	rr	–	rr	–	–	–	–	–
Metridia lucens, Boeck.	-	–	–	–	–	–	–	r	r	+	r	r	c	+	–	r	+	r	+	–	rr	r	+	r	r	r
Oithona nana, Giesbr.	–	rr	rr	–	–	–	–	–	–	–	–	–	–	–	–	rr	rr	rr	rr	r	r	–	–	–	rr	–
similis, Claus.	–	+	r	rr	r	rr	+	rr	–	–	–	r	r	rr	–	r	–	–	rr	+	rr	r	–	rr	+	r
Paracalanus parvus, Claus.	-	r	r	+	r	+	+	r	r	r	r	r	r	r	r	r	r	r	+	r	+	c	+	+	+	c
Pseudocalanus elongatus, Boeck.	+	+	r	c	c	c	+	+	+	c	c	c	cc	c	cc	cc	cc	cc	cc	cc	cc	c	c	+	+	c
Temora longicornis, O. F. Mull	c	–	–	c	c	c	+	c	c	+	+	–	–	+	–	rr	+	r	rr	c	rr	rr	–	–	rr	r
Crustacea cetera.																									
Anchialus agilis, G. O. Sars.	–	–	–	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	rr	–	–	–	–	–
Apherusa Clevei, G. O. Sars.	–	–	–	–	–	–	–	–	–	rr	rr	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	–
Carididae larvae	rr	–	–	r	r	r	–	+	+	+	+	+	+	+	–	–	r	r	+	+	r	+	rr	rr	rr	r
Cirripedia larvae	–	+	r	–	+	+	c	r	+	+	+	–	rr	rr	–	–	–	–	–	–	–	–	–	–	–	–
Euthemisto gracillipes, Norman	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–		–	–	–	–	rr	–	–	rr	rr	rr
Evadne Nordmanni, Loven	–	r	–	+	c	c	+	+	rr	rr	rr	rr	+	cc	–	rr	–	–	–	–	rr	–	–	–	–	–
Nauplius	–	+	+	–	rr	–	c	–	r	r	–	+	+	+	–	c	+	+	+	+	+	+	r	r	+	+
Nictyphanes Couchii, Bell.	–	–	–	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	rr	–
Podon intermedius, Lilljeb.	–	–	–	r	r	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–
Zoeae	r	rr	rr	+	r	r	–	+	+	+	+	+	--	r	–	r	–	+	r	r	r	+	rr	r	r	r
Zoeae, Megalopa stage	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	rr	–	–	–	–
Mollusca.																									
Gasteropoda larvae	–	–	–	–	rr	rr	–		–	–		–	–	–	–	–	–	–	–	–	–	–	–	rr	–	–
Lamellibranchiata larvae	–	–	–	–	rr	–	–		–	–		–	–	–	–	–	–	–	–	–	–	rr	–	–	–	–
Limacina retroversa, Flem.	–	r	–	–	–	–	–	rr	–	rr		rr	–	–	–	–	–	–	rr	–	–	+	–	–	r	–
Tunicata.																									
Oikopleura dioica, Fol.	r	r	r	+	+	rr	r	rr	r	+	r	r	r	–	–	–	–	–	–	r	c	–	–	–	–	rr
Vertebrata.																									
Fish ova	r	–	–	–	r	rr	rr	rr	rr	rr	rr	rr	rr	r	–	–	–	–	r	rr	rr	rr	–	–	–	rr
Fish larvae	rr	–	–	–	rr	r		r	r	rr	rr	–		r	–	–	–	–	–	rr	–	rr	–	–	–	–

TABLE No. III.—FOOD AND PLANKTON TABLE. Western Area, 1906.

Month . . .	February							March	
Date . . .	12	12	12	13	14	14	24	12	24
Positions where samples were taken.	8 m. S. of Newlyn .	8 m. S. of Newlyn .	Sevenstones .	6 m. S.E. of Mousehole .	9 m. S.S.W. of Mousehole	9 m. S.S.W. of Mousehole	Sevenstones .	Sevenstones .	Sevenstones .
S = Stomach. P = Plankton sample.	P	S	P	P	P	S	P	P	P
Sample No.	3	64	2	4	5	65	6	7	8
Species—									
Acartia Clausi Giesbr . . .	–	–	–	r r	–	–	r r	r r	r r
Calanus finmarchicus Gunn . .	+	+	c	+	+	r r	+	+	+
Centropages typicus Kroyer . .	–	–	r r	–	r r	–	–	r	r r
Metridia lucens Boeck . . .	r r	r	–	r	r	r r	–	–	–
Paracalanus parvus Claus. . .	+	r r	r r	+	+	–	r	r	r
Pseudocalanus elongatus Boeck . .	+	+	r	+	+	r r	r	+	+
Temora longicornis O. F. Mull . .	–	–	r r	–	–	–	–	–	–
Zoeae	–	–	r r	r r	r r	r r	r	r	r
Sagitta bipunctata Quoy and Gaim .	c	–	c	c	+	r	c	+	+
Oikopleura dioica Fol . . .	+	c	–	c	+	+	r r	+	c
Phytoplankton chiefly Phaeocystis globosa Scherffel	–	c	–	–	–	c	–	–	–
No. of Fish taken in "hundreds." (Hundred = 120 Fish.)	–	–	–	–	–	$\frac{1}{5}$	–	–	–

Month . . .	April												
Date . . .	10	19	21	21	23	23	24	24	24	24	26	26	26
Positions where samples were taken.	Sevenstones . .	56 m. N.N.W. of S. Ives Head	20 m. S.W. of Wolf .	20 m. S.W. of Wolf .	15 m. S.W.×W. of Lizard	30 m. S.W.×W. ½ W. of Lizard	30 m. S.W. of Wolf .	14 m. S.W.×W. of Wolf .	10 m. N.W. ½ N. of Longships	5 m. S.S.W. ½ W. of Mousehole	Sevenstones .	35 m. N. of Longships .	35 m. N. of Longships
S = Stomach. P = Plankton sample.	P	S	P	S	P	P	P	P	P	P	P	P	S
Sample No.	9	66	10	67	14	15	16	17	18	19	21	22	68
Species—													
Acartia Clausi Giesbr . . .	+	r	+	+	c	c	c	c	c	c	+	+	r r
Calanus finmarchicus Gunn . .	r	+	+	+	+	c	c	+	+	+	+	+	r
Centropages typicus Kroyer . .	r	r r	r	r r	+	+	r	r	+	c	r	r r	–
Metridia lucens Boeck . . .	–	r	r	r	r r	+	c	c	c	+	+	+	r
Paracalanus parvus Claus. . .	r r	c c	+	c	+	+	+	+	+	r	+	+	+
Pseudocalanus elongatus Boeck . .	–	c c	c	+	+	+	+	+	+	+	+	+	r
Temora longicornis O. F. Mull . .	–	r r	–	r r	r	r	–	r	+	+	–	r r	–
Zoeae	–	r	r	–	+	+	c	+	+	r	+	+	c
Sagitta bipunctata Quoy and Gaim .	–	+	c	r	+	c	c	c	+	r	+	+	r r
Oikopleura dioica Fol . . .	+	r	+	c c	c	c	+	+	+	+	r	r	–
Phytoplankton chiefly Phaeocystis globosa Scherffel	–	r r	c	c c	+	r	r	c	c c	c	c c	c c	c c
No. of Fish taken in "hundreds." (Hundred = 120 Fish.)	–	20	50	–	–	–	–	–	–	–	–	–	30

Month . . .	May											
Date . . .	1	5	10	10		10	15	16	18	19	19	23
Positions where samples were taken.	12 m. S.S.W. of Wolf *	35 m. S.S.W. of Bay .	18 m. S. of Lizard .	18 m. S. of Lizard .	10 m. S.S.E. of Bishop .	Sevenstones .	Stat. E. 5 .	50 m. W.×S. of Wolf	50° 47′ N.×6° 36′ W.	Stat. E. 6 .	Stat. E. 7 .	Sevenstones .
S = Stomach. P = Plankton sample.	P	P	P	S	S	P	P	S	P	P	P	P
Sample No.	23	24	26	69	70	25	27	71	28	29	30	31
Species—												
Acartia Clausi Giesbr . . .	r	+	r	–	r r	r	r r	r r	r r	r	c	+
Calanus finmarchicus Gunn . .	r	c	c	c	+	c c	c	c c	c	+	+	+
Centropages typicus Kroyer . .	–	r	r r	–	+	r r	r r	r r	r r	r r	r	r
Metridia lucens Boeck . . .	–	r	r r	–	–	r	+	r	+	r r	–	r r
Paracalanus parvus Claus. . .	–	+	r	r	r	+	+	+	+	r r	c	+
Pseudocalanus elongatus Boeck . .	–	c	+	+	+	+	c	+	c c	+	c	+
Temora longicornis O. F. Mull . .	–	–	+	r	+	–	–	–	r r	r	r r	+
Zoeae	r r	+	c	c	r	c	r	+	+	+	+	r
Sagitta bipunctata Quoy and Gaim .	r	+	+	r	c c	+	c	r	c	+	c	+
Oikopleura dioica Fol . . .	r	c	c	c	+	c	r r	r	r	r	r	+
Phytoplankton chiefly Phaeocystis globosa Scherffel	–	–	+	c	–	–	–	–	–	–	–	+
No. of Fish taken in "hundreds." (Hundred = 120 Fish.)	–	–	–	–	–	–	–	–	–	–	–	–

Month . . .	June									
Date . . .	5	5	7	7	8	13	13	17	17	23
Positions where samples were taken.	70 m. W.S.W. of Wolf .	70 m. W.S.W. of Wolf .	60 m. S.W.×W. of Scilly	60 m. S.W.×W. of Scilly	Sevenstones .	25 m. W.×S. of Bishop .	25 m. W.×S. of Bishop .	60 m. S.W.×W. of Bishop	60 m. S.W.×W. of Bishop	Sevenstones .
S = Stomach. P = Plankton sample.	P	S	P	S	P	P	S	P	S	P
Sample No.	32	72	33	73	34	35	74	36	75	37
Species—										
Acartia Clausi Giesbr . . .	r r	r r	r r	r	c	r r	r	r r	r r	r
Calanus finmarchicus Gunn . .	c c	c c	c c	c c	+	c c	c c	c c	c	c
Centropages typicus Kroyer . .	r	–	–	r r	c	+	r	r	r r	+
Metridia lucens Boeck . . .	r	r	r	r	–	r	+	r	r r	–
Paracalanus parvus Claus. . .	+	+	+	c c	r r	+	c c	+	+	+
Pseudocalanus elongatus Boeck . .	c	+	c	c c	r	+	c c	c	c	+
Temora longicornis O. F. Mull . .	–	–	–	–	r	–	–	–	–	–
Zoeae	r	r r	–	r r	–	–	r	r r	r	r
Sagitta bipunctata Quoy and Gaim .	+	r	r	r	r r	+	r	+	r	r
Oikopleura dioica Fol . . .	r	r	–	r r	r	r r	–	r	r r	r
Phytoplankton chiefly Phaeocystis globosa Scherffel	r	–	–	–	–	–	–	–	–	–
No. of Fish taken in "hundreds." (Hundred = 120 Fish.)	–	20	–	–	–	–	30	–	–	–

AND PLANKTON TABLE, WESTERN AREA, 1907.

				May										
16	17	17	30	1	1	1	1	1	2	2	9	9	14	14
10 m. N. ¾ W. of Longships .	20 m. N. of Longships .	10 m. S.W. of Wolf .	50 m. S.S.W. of Wolf .	30 m. W. of Bishop .	60 m. W.S.W. of Wolf .	35 m. W.×S. of Bishop .	30 m. W.×N. of Bishop .	40 m. S.S.W. of Kinsale .	28 m. S.W. of Bishop .	14 m. S. of Bishop .	28 m. W.×S. of Bishop .	28 m. W.×S. of Bishop .	6 m. W.S.W. of Bishop .	50 m. S.W.×S. of Mousehole .
P	P	P	S	S	S	S	S	S	S	S	P	S	S	S
46	**47**	**48**	**89**	**90**	**91**	**92**	**93**	**94**	**95**	**96**	**49**	**97**	**98**	**99**
r	+	+	–	–	–	–	rr	–	rr	rr	r	rr	rr	+
c	c	cc	cc	cc	c	cc	cc	c	cc	cc	cc	cc	cc	c
r	r	r	–	r	–	–	–	–	–	–	rr	–	rr	–
r	+	r	rr	rr	–	rr	rr	–	rr	rr	r	rr	r	–
+	c	c	cc	c	+	cc	cc	c	cc	cc	c	cc	cc	c
c	+	+	–	rr	rr	r	–	rr	–	–	–	–	–	c
+	+	+	–	–	–	–	–	cc	–	–	+	r	r	r
+	+	+	–	–	–	–	–	–	rr	–	–	–	–	–
r	+	r	–	–	+	rr	rr	rr	–	–	r	–	–	–
c	c	cc	–	–	–	–	+	c	–	–	–	–	–	–
–	–	–	40	200	400	400	90	50	300	200	–	100	120	100

17	17	17	17	17	17	17	18	18	18	19	21	23	23	23
42 m. S.W. of Wolf .	40 m. W. of Bishop .	20 m. S.W. of Scilly .	Stat. E. 30. .	Stat. E. 6 .	49.49. N.×6.57 W. .	49.48 N.×7.10 W. .	Stat. E. 25 .	49.24 N.×6.36 W. .	Stat. E. 5. .	Stat. E. 7 .	18 m. W.N.W. of Bishop .	35 m. S.W. of Wolf .	30 m. S.W. of Mousehole .	60 m. S.W. of Mousehole .
S	S	S	P	P	P	P	P	P	P	P	P	S	S	S
100	**101**	**102**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**103**	**104**	**105**
r	r	r	+	c	r	c	r	+	+	+	c	+	+	+
cc	cc	cc	cc	+	cc	cc	cc	+	cc	c	c	cc	r	c
–	–	–	r	+	–	r	–	r	r	c	r	+	+	+
r	r	r	c	+	–	r	+	r	+	–	rr	+	+	r
cc	cc	cc	cc	c	cc	cc	cc	cc	cc	cc	cc	cc	c	cc
–	–	–	–	+	–	r	+	r	rr	+	rr	r	cc	+
+	rr	+	–	r	–	r	r	+	+	r	r	r	r	r
–	–	–	+	+	–	–	+	+	+	+	r	rr	–	+
–	–	–	r	–	–	–	–	–	–	–	c	–	–	–
–	–	–	–	–	–	–	–	–	–	–	–	c	–	–
–	400	300	–	–	–	–	–	–	·	–	–	20	7	20

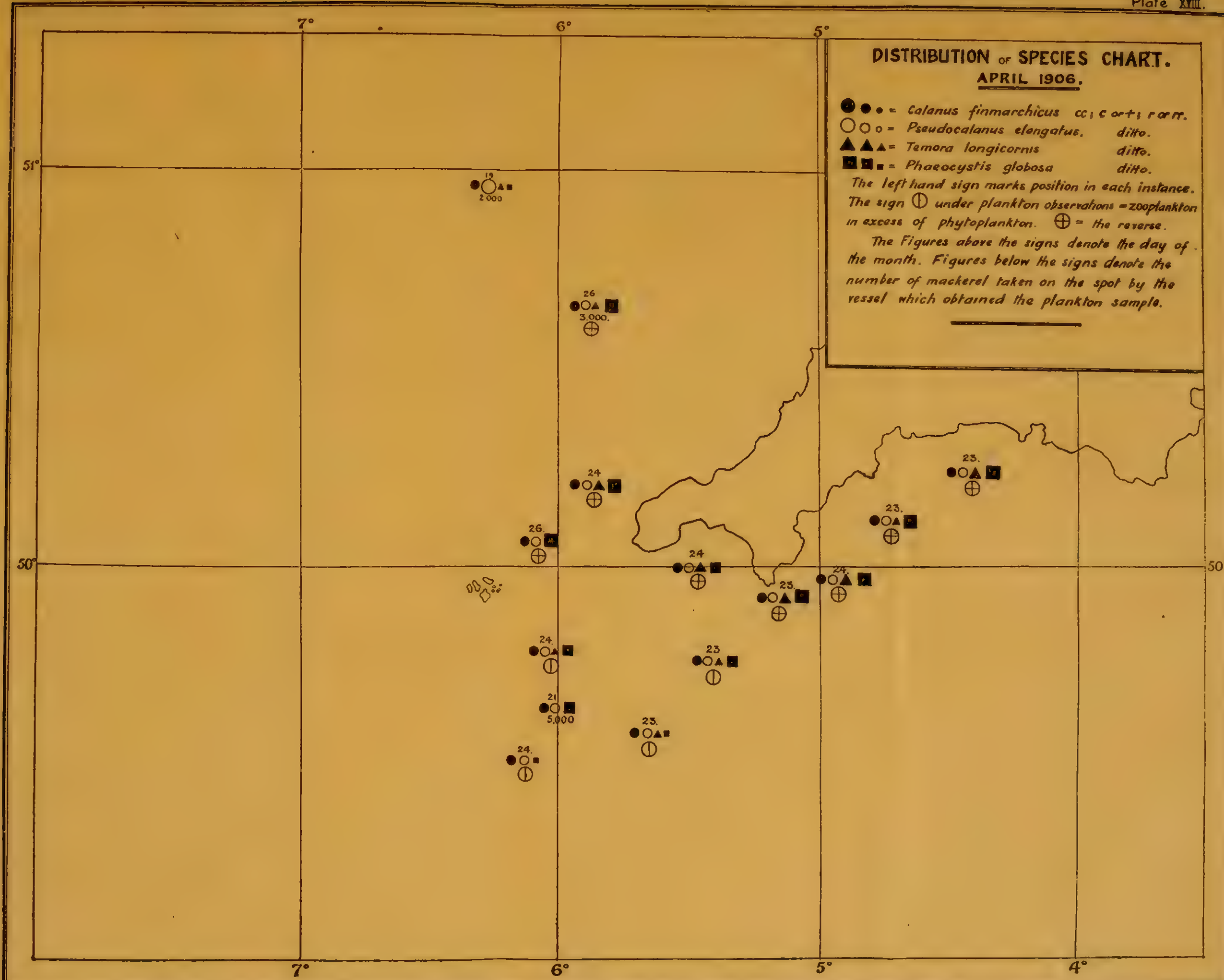
				June					
29	30	31	31	1	3	4	6	14	14
55 m. S. of Mousehole .	45 m. S.W.×S. of Newlyn .	60 m. W.S.W. of Wolf. .	60 m. W.S.W. of Wolf .	45 m. S.W. of Bishop .	55 m. W.S.W. of Wolf. .	30 m. W.S.W. of Bishop .	50 m. S.W. of Wolf .	55 m. S. of Newlyn .	55 m. S. of Newlyn .
P	S	P	S	S	S	P	P	P	S
59	**106**	**60**	**107**	**108**	**109**	**61**	**62**	**63**	**110**
rr	rr	–	rr	rr	–	rr	rr	r	rr
cc	cc	cc	cc	+	cc	cc	cc	c	cc
rr	rr	rr	rr	–	r	rr	–	–	r
r	rr	+	r	r	–	r	r	r	+
c	cc	c	cc	c	cc	+	+	c	cc
rr	–	–	–	c	r	–	rr	r	–
+	r	rr	rr	+	r	r	r	r	+
+	–	r	rr	rr	–	+	+	+	+
–	–	–	–	–	–	–	–	rr	–
–	–	–	–	–	–	–	–	–	–
–	40	–	14	7	90	–	–	–	30

TABLE No. V.—FOOD AND PLANKTON TABLE. Plymouth to Lizard Area, 1907.

Month	Mar.	Mar.	April	April	April	April	April	April	April	April	April
Date	24	26	4	4	16	20	26	26	27	27	30
Positions where samples were taken.	25 m. S. of Start (on Ground)	21 m. S.×W. ¾ W. of Start	10 m. S.W. of Eddystone	12 m. S. of Lizard	12 m. S. ½ W. of Looe	5 m. S. of Looe	8 m. S. of Dodman Point	15 m. S.E. of Dodman Point	17 m. S.×W. of Dodman Point	8 m. S.W. of Eddystone	Near the Eddystone
S = Stomach. P = Plankton	S	P	S	S	P	S	S	S	P	S	S
Sample No.	111	38	112	113	41	114	115	116	42	117	118
Species.											
Acartia Clausi, Giesbr.	rr	–	–	–	+	+	+	+	c	+	r
Calanus finmarchicus, Gunn	–	r	r	–	+	r	r	+	r	r	+
Pseudocalanus elongatus, Boeck.	rr	+	+	–	c	+	+	+	c	+	+
Temora longicornis, O. F. Mull.	cc	c	c	–	c	cc	cc	cc	c	cc	c
Zoeae.	rr	rr	–	–	+	r	–	rr	r	r	r
Sagitta bipunctata, Quoy and Gaim.	–	r	–	–	+	r	–	–	+	–	r
Oikopleura dioica, Fol.	cc	r	cc	–	+	rr	–	–	+	–	rr
Young Fish or Crystallogobius	–	–	–	–	–	–	–	–	–	–	rr
Phytoplankton, chiefly Phaeocystis globosa Scherffel	cc	+	cc	–	cc	+	–	–	cc	–	r
No. of Mackerel taken in "hundreds" (Hundred = 120 fish)	60	–	5	5	–	10	30	40	–	40	7

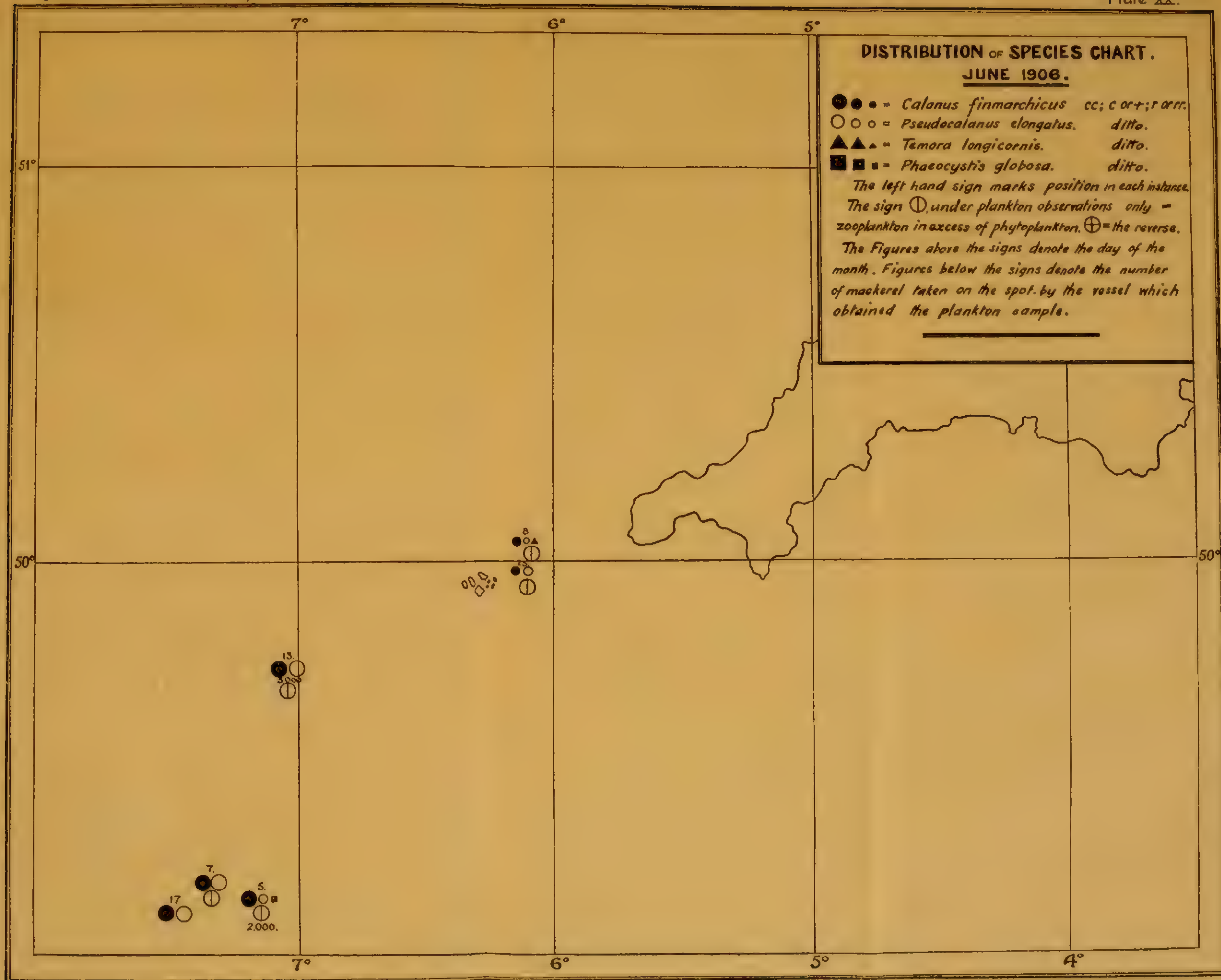
Month	May	May	May	May	May	May	May	May	May	May
Date	6	6	13	17	17	24	27	28	28	30
Positions where samples were taken.	3 m. off Downderry	4 m. S.E. of Looe	6 m. N.W. of Eddystone	3 m. W.N.W. of Eddystone	5 m. E.S.E. of Eddystone	6 m. W.×S. of Eddystone	50 m. S.W. of Eddystone	40 m. S.W.×S. of Eddystone	9 m. E.S.E. of Eddystone	40 m. S.E. of Start
S = Stomach. P = Plankton	S	S	S	S	S	S	S	S	S	S
Sample No.	119	120	121	122	123	124	125	126	127	128
Species.										
Acartia Clausi, Giesbr.	rr	rr	–	rr	–	–	rr	–	rr	rr
Calanus finmarchicus, Gunn	c	+	+	rr	+	–	+	+	+	r
Pseudocalanus elongatus, Boeck.	+	+	+	r	+	–	+	+	+	r
Temora longicornis, O. F. Mull.	cc	cc	cc	cc	cc	cc	c	cc	cc	cc
Zoeae.	c	+	+	r	cc	cc	–	+	c	r
Sagitta bipunctata, Quoy and Gaim.	+	c	cc	r	–	–	cc	r	–	–
Oikopleura dioica, Fol.	rr	–	–	–	–	–	rr	–	–	–
Young Fish or Crystallogobius	rr	rr	c	–	r	c	–	c	+	–
Phytoplankton, chiefly Phaeocystis globosa Scherffel	c	–	–	–	–	–	c	–	–	–
No. of Mackerel taken in "hundreds" (Hundred = 120 fish)	–	10	10	–	–	10	–	12	½	8

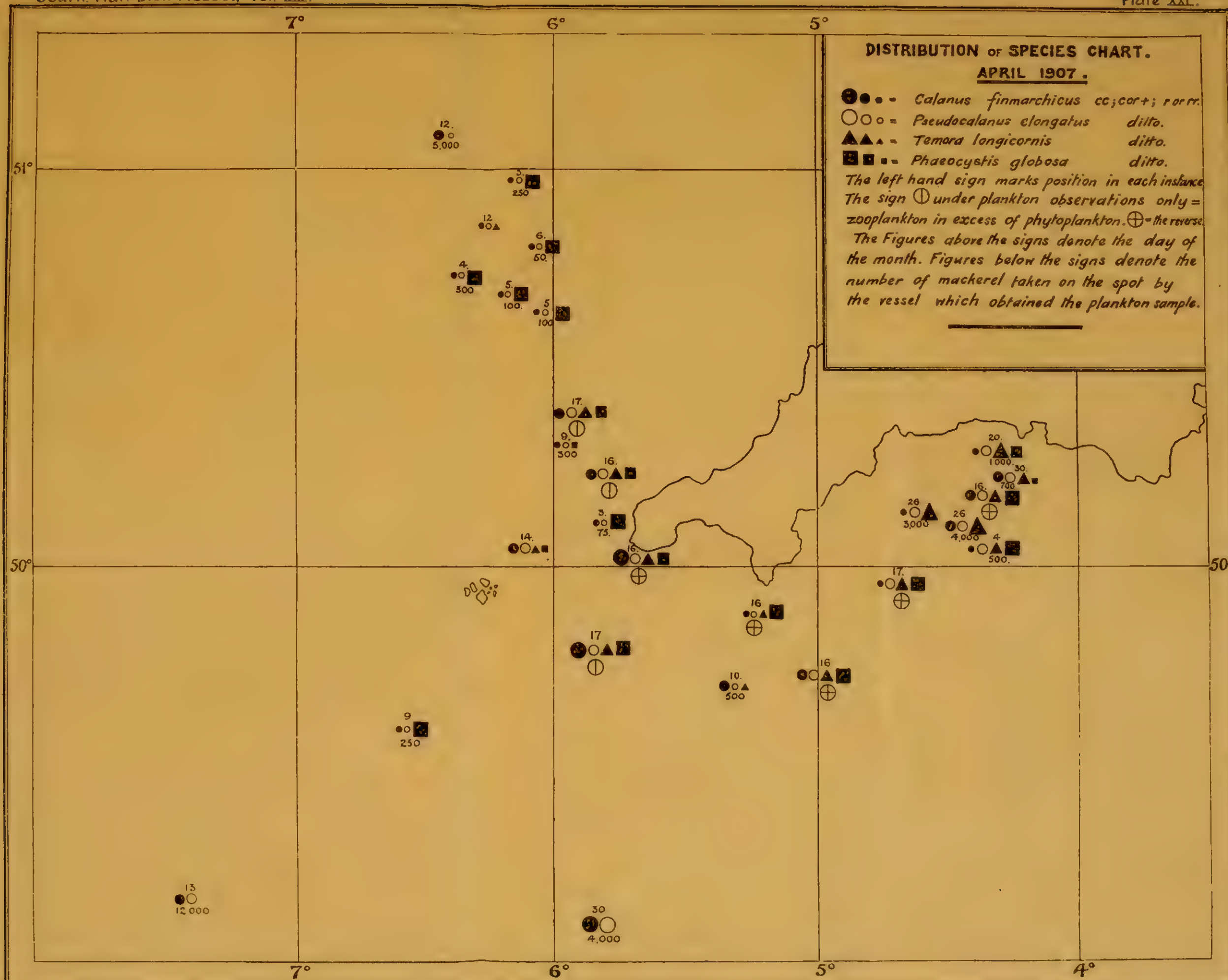
Month	June	June	June	June	June	June	June	June	June	June	June	July	July
Date	3	14	14	15	17	17	17	19	19	21	24	16	18
Positions where samples were taken.	30 m. S.W. of Eddystone	4 m. S. of Eddystone	12 m. S.E. of Eddystone	10 m. S. of Eddystone	12 m. W. of Eddystone	7 m. S.E.×E. of Eddystone	12 m. S. of Eddystone	4 m. S.S.E. of Eddystone	8 m. S.E. of Eddystone	10 m. S.S.W. of Eddystone	20 m. S.W. of Eddystone	Off Penlee (from Seine)	Off Portwrinkle (from Seine)
S = Stomach. P = Plankton	S	S	S	S	S	S	S	S	S	S	S	S	S
Sample No.	129	130	131	132	133	134	135	136	137	138	139	140	141
Species.													
Acartia Clausi, Giesbr.	–	–	–	–	–	–	–	–	–	–	–	–	–
Calanus finmarchicus, Gunn	+	+	rr	rr	–	–	–	rr	+	rr	r	–	–
Pseudocalanus elongatus, Boeck.	+	+	r	r	–	–	–	r	rr	rr	rr	–	–
Temora longicornis, O. F. Mull.	c	c	cc	cc	–	c	rr	c	r	c	cc	–	–
Zoeae.	c	cc	rr	c	–	c	cc	+	r	–	c	–	–
Sagitta bipunctata, Quoy and Gaim.	cc	–	–	–	–	–	–	–	–	–	–	–	–
Oikopleura dioica, Fol.	–	–	–	–	–	–	–	–	–	–	–	–	–
Young Fish or Crystallogobius	–	c	r	r	cc	+	cc	c	c	+	–	cc	cc
Phytoplankton, chiefly Phaeocystis globosa Scherffel	–	–	–	–	–	–	–	–	–	–	–	–	–
No. of Mackerel taken in "hundreds" (Hundred = 120 fish)	8	8	5	4	25	30	75	5	25	10	25	20	50

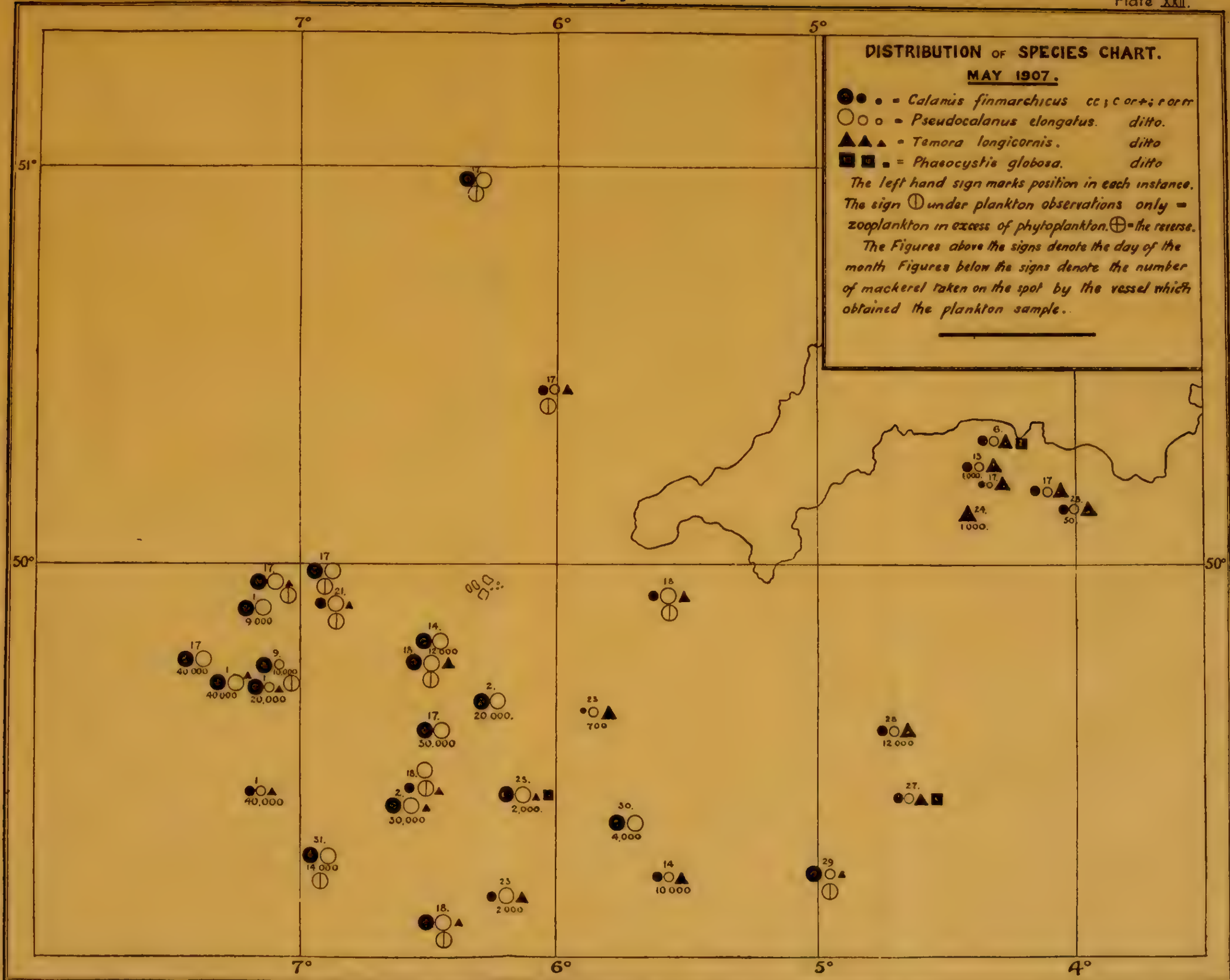

DISTRIBUTION OF SPECIES CHART.
APRIL 1906.
= Calanus finmarchicus cc; c or +; r or rr.
= Pseudocalanus elongatus. ditto.
= Temora longicornis ditto.
= Phaeocystis globosa ditto.
The left hand sign marks position in each instance.
The sign ⦶ under plankton observations = zooplankton in excess of phytoplankton. ⊕ = the reverse.
The Figures above the signs denote the day of the month. Figures below the signs denote the number of mackerel taken on the spot by the vessel which obtained the plankton sample.
7°
6°
5°
4°
51°
50°
19
2,000
26
3,000.
24
26.
24
23.
23.
24.
23.
24.
23
21
5,000
23.
24.

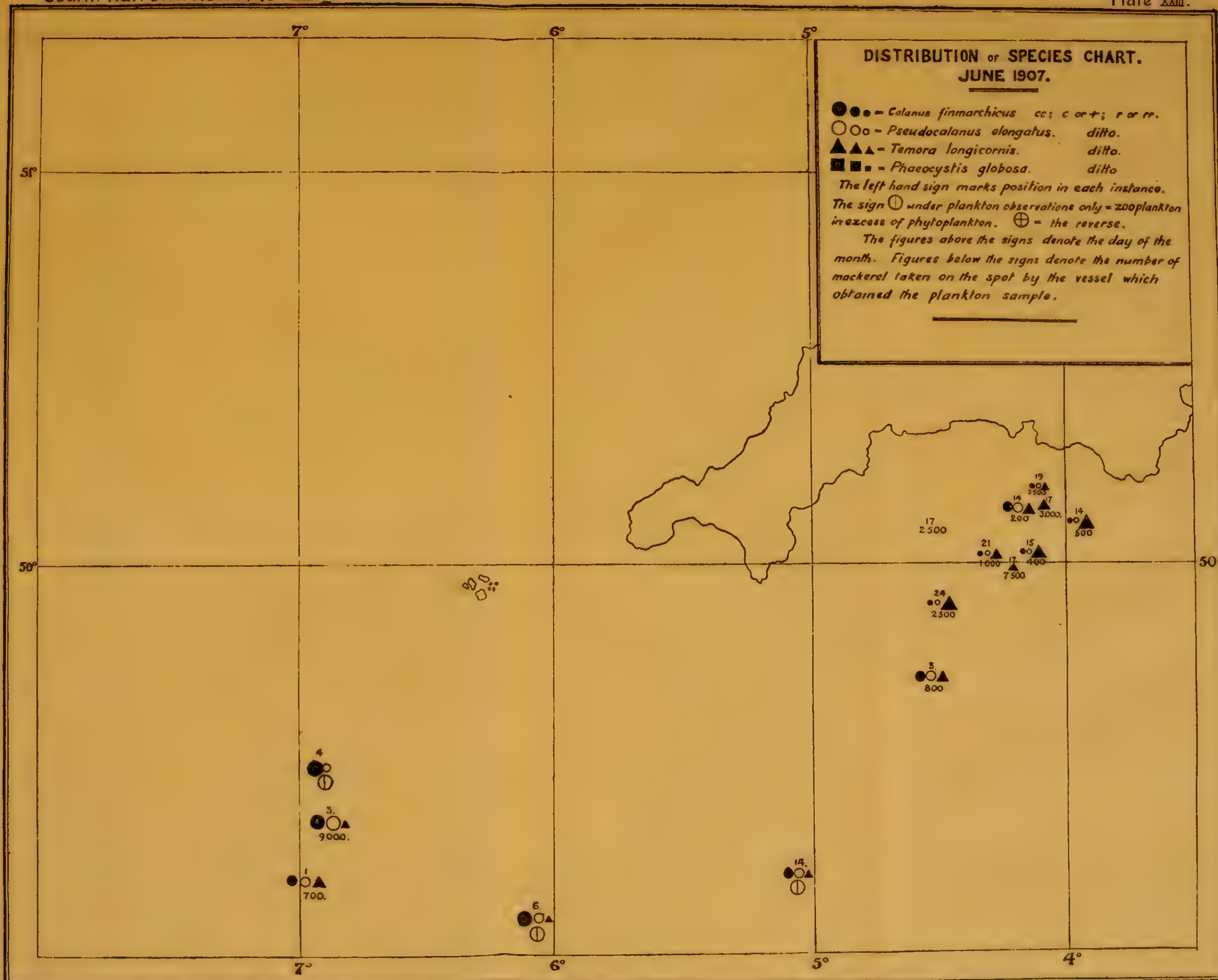
To face p. 302.


DISTRIBUTION OF SPECIES CHART.
MAY 1906.
= Calanus finmarchicus cc; c or +; r or rr.
= Pseudocalanus elongatus ditto.
= Temora longicornis. ditto.
= Phaeocystis globosa. ditto.
The left hand sign marks position in each instance.
The sign under plankton observations = zooplankton in excess of phytoplankton. - the reverse.
The Figures above the signs denote the day of the month. Figures below the signs denote the number of mackerel taken on the spot by the vessel which obtained the plankton sample.
7°
6°
5°
4°
51°
50°
18
19.
10.
23
19.
10.
16.
5.
15


DISTRIBUTION OF SPECIES CHART.
JUNE 1906.
= Calanus finmarchicus cc; c or +; r or rr.
= Pseudocalanus elongatus. ditto.
= Temora longicornis. ditto.
= Phaeocystis globosa. ditto.
The left hand sign marks position in each instance.
The sign ⦶, under plankton observations only = zooplankton in excess of phytoplankton. ⊕ = the reverse.
The Figures above the signs denote the day of the month. Figures below the signs denote the number of mackerel taken on the spot by the vessel which obtained the plankton sample.
7°
6°
5°
4°
51°
50°
8
13.
3,000
7.
17
5.
2,000.


DISTRIBUTION OF SPECIES CHART.
APRIL 1907.
Calanus finmarchicus cc; c or +; r or rr.
Pseudocalanus elongatus ditto.
Temora longicornis ditto.
Phaeocystis globosa ditto.
The left hand sign marks position in each instance
The sign ⦶ under plankton observations only = zooplankton in excess of phytoplankton. ⊕ = the reverse.
The Figures above the signs denote the day of the month. Figures below the signs denote the number of mackerel taken on the spot by the vessel which obtained the plankton sample.
7°
6°
5°
4°
51°
50°


DISTRIBUTION OF SPECIES CHART.
MAY 1907.
= Calanus finmarchicus cc; c or +; r or rr
= Pseudocalanus elongatus. ditto.
= Temora longicornis. ditto
= Phaeocystis globosa. ditto
The left hand sign marks position in each instance. The sign ⦶ under plankton observations only = zooplankton in excess of phytoplankton. ⊕ = the reverse.
The Figures above the signs denote the day of the month Figures below the signs denote the number of mackerel taken on the spot by the vessel which obtained the plankton sample.
7°
6°
5°
4°
51°
50°


DISTRIBUTION OF SPECIES CHART.
JUNE 1907.
– Calanus finmarchicus cc; c or +; r or rr.
– Pseudocalanus elongatus. ditto.
– Temora longicornis. ditto.
– Phaeocystis globosa. ditto
The left hand sign marks position in each instance.
The sign under plankton observations only = zooplankton in excess of phytoplankton. = the reverse.
The figures above the signs denote the day of the month. Figures below the signs denote the number of mackerel taken on the spot by the vessel which obtained the plankton sample.
7° 6° 5° 4°
51° 50°
4
5.
9000.
1
700.
6.
14.
5.
800
24
2500
21
1000
17
7500
15
400
17
2500
14
200
17
3000.
19
2500
14
600

On an Experiment in the Keeping of Salmon (*Salmo salar*) at the Plymouth Laboratory.

By

L. R. Crawshay, M.A.,

Assistant Director.

With Plate XXIV.

For the past two and a half years (1906–8) some salmon, which were reared at the Endsleigh Fishery, have been kept under observation in the aquarium of the Plymouth Laboratory.

In sending these fish as smolts to the Laboratory, the Duke of Bedford wished more particularly to obtain information on two questions: firstly, the character of the food of the salmon during its sojourn in the sea, and secondly, the period of that sojourn intervening between the smolt and grilse stages. These and other points of interest that have arisen will be considered in order in giving a general account of the experiment.

The smolts were brought from Endsleigh at two years old, and introduced into the aquarium in two lots (of twenty and thirty) on February 6th and March 1st, 1906, respectively. The actual weight and measurement were not taken at the time, but Mr. E. C. Rundle informs me he has ascertained that the average weight may be placed at 4–5 oz. and the average length at 8–10 inches. The fish have been largely under the charge of Mr. A. J. Smith, and it is upon his detailed notes that the present account is based.

For the accommodation of the smolts, one of the aquarium tanks was emptied and brought into communication with the fresh-water supply, the water being led into the tank by means of a rubber hose-pipe, and kept running.

The first twenty smolts were put into this tank on February 6th, 1906, and allowed to remain in the fresh water for two days. Transference to sea-water was then effected very gradually, at a rate of inflow increasing from day to day, as follows:—

February 8th, 11.45 a.m.	Fresh water 1000 cc. per 15 seconds	
	Sea ,, ,, ,, 75 ,,	
,, 9th, 10.30 a.m. . .		Density of water in tank 1·001
	Fresh water 1000 cc. per 35 seconds	
	Sea ,, ,, ,, 75 ,,	
,, 10th, 10.30 a.m. . .		Density of water in tank 1·005
	Fresh water 1000 cc. per 47 seconds	
	Sea ,, ,, ,, 31 ,,	
,, 12th, 10.0 a.m. . .		Density of water in tank 1·016
	Fresh water 1000 cc. per 60 seconds	
	Sea ,, ,, ,, 31 ,,	
,, 13th, 10.30 a.m. . .		Density of water in tank { Top 1·017, Bot. 1·018
		Temp. 46° F.
,, 14th		Density of water in tank 1·018
	Fresh water shut off	
	Sea ,, 1000 cc. per 31 seconds	
,, 15th . .	Two more jets of sea water turned on. (One smolt died.)	
,, 16th, 10.0 a.m. . .		Density of water in tank 1.027

The water having now approximately reached the normal salinity of the water in the reservoirs, the supply was connected up with the general circulation, i.e. nine days after the transference began. The digestive tract of the smolt that died on the 15th was found to be quite empty. Feeding on the whole had been fairly good. On February 27th these nineteen smolts were removed to a larger tank. On March 1st the second lot of smolts, thirty in number, were brought from Endsleigh, and placed in fresh water in the tank now vacated by the others. Their transference to sea water was completed in about one-third of the time occupied for that of the preceding lot, and as follows:—

March 5th . .	Fresh water 1000 cc. per 18 seconds	
	Sea ,, ,, ,, 33 ,,	
,, 6th		Density of water in tank 1·007
	Fresh water 1000 cc. per 30 seconds	
	Sea ,, ,, ,, 10 ,,	
,, 7th		Density of water in tank 1·015
	Fresh water supply turned off	
	Sea water 1000 cc. per 10 seconds	
,, 8th		Density of water in tank 1·026
	Supply connected up with general circulation.	

The transference of the second lot was therefore completed in three

days. Before it began, one of the smolts jumped from the fresh-water tank, over the barrier, into the sea-water tank adjoining. It was left in sea water afterwards, and suffered no harm. The same thing happened to a second individual on the first night after the change began (March 5th).

On March 10th this second lot of smolts was put into the large tank with the others. This tank, which now contained forty-nine smolts, was used throughout to accommodate the survivors as long as the salmon remained at the Laboratory. Its inside dimensions are 15·7 feet in length, 9 feet in width, and 4·4 feet in depth of water, giving a capacity of 621 cubic feet. It was fed by eight jets, giving a total normal inflow of about 385 cc. per second, and its position, partly screened from the direct light by a dark-coloured blind, is such that its lighting may be described as moderately low and constant. The back, the ends, and the floor of the tank are formed of slate, and all uprights or other portions of the framework are similarly dark in colour. Air was supplied entirely by the force of the water from the several jets striking the surface, which was sufficient to carry the fine air-bubbles nearly or quite to the bottom of the tank.

Feeding.—The smolts were fed twice a day, and often three times. On the first day or two the food given them was broken biscuit and prepared fish and flesh foods previously soaked, of the same kind as that used at Endsleigh. This was then varied with raw bullock's liver cut into small pieces, and the preference for this latter soon became so strong that the other was very shortly discarded altogether. This was the case with both lots of smolt. When the transference to sea water was about half completed, it was found that the common inter-tidal marine worms of the genus *Nereis* (*N. diversicolor*) were taken very readily. About the time of the completion of the change a distinct loss of appetite was shown by several of the smolts for a few days. But, on the whole, feeding was fairly good during the interval, and this was particularly the case with the second lot, where the transference was brought about more rapidly. After the change to sea water, liver was taken with the same readiness as previously. *Nereis* was at times taken when liver was refused, but beyond this little preference was shown between the two.

Experiments in feeding with marine animals other than *Nereis* gave entirely negative results. Among others, trials were made on several occasions with the following species:—*

* It is to be regretted that herring was never tried. But the keeping of young herring alive for any length of time, even when they are obtainable, is a matter of very great difficulty.

Living Shrimps (*Crangon*).
,, Prawns (*Palaemon*).
,, *Pandalus annulicornis* and *P. brevirostris.*
Cut Squid (*Loligo*).
,, Scallop (*Pecten*).
Living Pollack (*Gadus pollachius*), about 2 inches long.
,, Gobies (*Gobius minutus* and *G. ruthensparri*).
Cut Plaice (*Pleuronectes platessa*).

The salmon were seen by Dr. Allen to take hold of some of the shrimps, though afterwards releasing them, and to show a certain interest in some of the small fish. But there was no evidence of their having swallowed any of these objects of food, and the only conclusion to be drawn is that they entirely refused them. Two of the smolts were kept for some time in a separate tank with two bass as companions, the only food offered them being shrimps, prawns, and gobies. Although the latter experiment was not conclusive, no evidence that any of these had been eaten by the salmon was obtained. On the first two or three days, while the smolts were still in fresh water, it was once or twice observed that fragments of the prepared foods (not liver) were picked up by them after reaching the bottom of the tank; but this never occurred afterwards, and even the living *Nereis*, which happened to reach the bottom, were allowed to remain there crawling about, without the salmon paying any attention to them. In marked contrast to this, some Rainbow Trout (*Salmo irideus*), which the Duke of Bedford has also sent to the Laboratory from Endsleigh, will commonly follow their food to the bottom, and continue to pick it up for some time after it has settled. These Rainbows, too, easily adapt themselves in sea water to the cut Squid (*Loligo*), and some other foods ordinarily given to the marine fishes.

First Spawning, 1906–7.—Signs of approaching maturity became apparent in the smolts towards the end of October, 1906, i.e. eight months after they were first passed into sea water. On October 31st and November 1st it was observed that scarcely any food was taken, and in some cases what was taken into the mouth was discarded again. During the previous week the fish had been growing darker in colour. They began to frequent the bottom of the tank and to lie there heavily. One of them lost the upright position, and died in a day or two afterwards (November 4th). It was accordingly decided to pass sixteen of the more advanced ones into fresh water. The process was begun on November 6th, and the change was made in a very similar manner to the reverse one in the preceding March. The time allowed

was from two to three days, and the whole of them were thus transferred to fresh water by November 15th. On November 9th, shortly after the change to fresh water, one of the males died. The testis was found to be nearly mature. The weight of this fish was very nearly 1 lb., and the length 13¾ inches. During this period one of the fish jumped from the fresh-water tank into a tank of sea water adjoining (cp. p. 305). After thirty-six hours it was put back into the fresh-water tank direct without any ill effects arising.

November 26th. All of the grilse were examined by Mr. McNicol, who has charge of the Duke of Bedford's Fishery. Apart from the deaths that had been recorded, it was found that five of the fish were missing. It can only be surmised that these had from time to time jumped over the barrier into the large adjoining tank and fallen victims to the turbot, nurse-hounds, and other large fish that occupied it. The number that remained was now thirty-five. Seven females were spawned on this day (November 26th), and the ova fertilized. The remainder were spawned on December 11th. Nearly the whole of these fertilized ova were taken to Endsleigh and there hatched under normal conditions both as regards numerical proportion and the period between fertilization and hatching. They were not kept under observation for long after hatching, and there was apparently no unusual feature arising in regard to size or otherwise in connection with their development. A few ova were retained at the Laboratory and hatched under tap water, but these did not long survive the feeding stage following absorption of the yolk-sac, owing no doubt merely to the unsuitable condition of the water supply with its irresistible tendency to nurture the growth of fungus and other vegetable organisms.

As regards feeding during this period of spawning, very little food was taken between the last week in October and the two respective dates of spawning, November 26th and December 11th, though feeding did not entirely cease for more than a day or so at a time. Within a few days after spawning, there was a marked change in this respect and by December 22nd the total consumption amounted to about ¾ lb. of liver per day, the weight of the fish at this time averaging about 1½ lb. Feeding continued at much the same point till the middle of February. It was then decided to turn the fish, numbering thirty-five, over to sea water, and this was done between February 19th and 20th. The change proved to be an unfortunate one, and the salmon at once ceased feeding. Between February 21st and 26th, seven of them died—five males and two females. These were found to still contain a quantity of ripe milt and ova respectively. Between February 25th

and 26th they were therefore returned to fresh water, and remained thus till March 15th. This change quickly brought about a return to feeding. On March 6th the daily consumption reached $\frac{3}{4}$ lb. of liver and a supply of *Nereis*, and the amount did not fall appreciably below this figure afterwards.

The return to sea water was made between March 15th and 19th, one female, which was found to be incompletely spawned, being lost in the process. Of the succeeding period in sea water in the spring and summer of 1907 there is little to record of interest. The food consumption rose steadily to 3 lb. of liver per day at the middle of May, and continued at about this point till the middle of August. From the latter date it began to fall, and on September 17th it dropped to $\frac{3}{4}$ lb.

At the end of September the salmon had to be moved, in order that the tank might be repaired. They were very susceptible to injury in handling, and four of them died before they were finally settled in their own tank.

Second Spawning, 1907–8. — The salmon, twenty-one in number, were transferred to fresh water between October 1st and 5th, about six weeks earlier than in the preceding year, feeding having by this time all but ceased. After this time and up to the date of spawning they continued to take a fair quantity of *Nereis* with some irregularity, but little or no liver was taken.

About half of them were spawned on November 15th, seven on November 29th, one on December 13th, and one on January 3rd. A large number of the fertilized ova were kept and hatched at the Laboratory, but the larvæ barely attained at most the complete absorption of the yolk-sac. How far the underlying causes were to be attributed to the inadequate conditions of the water supply as in the previous year, it is difficult to say, but two points were particularly noticeable in this case: (1) a common difficulty in rupturing the egg-membrane, and (2) a general weakness in the embryonic circulation which hindered communication with the distal portion of the yolk-sac and retarded its absorption. In consequence of the latter difficulty a constriction arising in the yolk-sac was the direct cause of death in the large majority of cases, and the two points taken together suggested a general sickliness that had been transmitted from the parents.

Attacks of fungus, which began to affect the salmon in the early part of December, 1907, had later assumed such proportions, with fatal results to several of the fish, that it was decided to transfer the remainder of them to sea water at an early date, and this was done between January 7th and 8th, 1908. Three deaths that occurred

within two days after the latter date may be attributed entirely to bad cases of fungus, and its attendant disease, too far gone to remedy, and apparently no ill effects resulted from this early return to sea water beyond a falling off in feeding for a few days afterwards.

Growth.—As previously stated the weight of the smolts when they were brought to the Laboratory in February and March, 1906, may be placed at 4 to 5 oz., and the length at 8 to 10 inches. On September 28th, 1906, one fish, taken as representing the average, weighed 1 lb. 8½ oz., and measured 16 inches in length. On November 26th, 1906, twenty-seven fish were weighed prior to spawning, but not measured. The weights of these fish were as follows:—

No.	Weight.		Sex.	Condition.
	lb.	oz.		
(1)	0	14	female	mature
(2)	1	3	,,	immature
(3)	1	4	,,	mature
(4)	1	4	male	,,
(5)	1	6	female	,,
(6)	1	6	,,	,,
(7)	1	6	,,	immature
(8)	1	6	male	mature
(9)	1	6	female	,,
(10)	1	6	,,	,,
(11)	1	6	,,	,,
(12)	1	6	male	,,
(13)	1	6	,,	immature
(14)	1	8	female	mature
(15)	1	8	male	immature
(16)	1	8	female	? spawned
(17)	1	10	,,	mature
(18)	1	10	male	nearly mature
(19)	1	12	female	mature
(20)	1	12	,,	immature
(21)	1	12	,,	mature
(22)	1	12	,,	,,
(23)	1	12	male	nearly mature
(24)	1	14	,,	immature
(25)	1	14	female	,,
(26)	1	14	,,	mature
(27)	2	0	,,	barren

It is remarkable that the above weights give an average which is exactly the same as the weight of the fish selected for trial on September 28th, viz. 1 lb. 8½ oz. It is quite conceivable that this particular fish chosen on that occasion slightly exceeded the true average, but it is evident that the average increase of weight in the two months' interval must have been very small. On the same

occasion (November 26th) seven of the females were weighed after spawning, with the following results:—

	lb.	oz.
(*a*)	1	2
(*b*)	1	4
(*c*)	1	4
(*d*)	1	4
(*e*)	1	8
(*f*)	1	9
(*g*)	1	10

These give an average of 1 lb. 6 oz. nearly. The weights cannot be compared individually with those taken before spawning, since to obviate as far as possible excessive physical strain on the fish the weights before and after spawning were not taken in any definite sequence. If, however, the average weight 1 lb. 6 oz. be compared with that of the twelve mature females enumerated in the first list (thus omitting No. 1 for obvious reasons), namely 1 lb. 8·5 oz., the average weight of spawn removed works out at $2\frac{1}{2}$ oz., or 10·2 per cent of the average weight of fish. Assuming, on the other hand, that the females spawned were the seven heaviest of the mature females in the first list, then the latter give an average weight of 1 lb. $10\frac{1}{2}$ oz., and the highest possible average weight of spawn removed would thus be $4\frac{1}{2}$ oz., or 17 per cent of the average weight of fish.

On November 15th, 1907, i.e. at the time of the second spawning, the weights were again taken of seven fish, of which the females were weighed both before and after spawning. These were as follows:—

Males	(1)	2 lb. 8 oz.	
	(2)	2 ,, 8 ,,	
Females	(1).	Before spawning, 2 lb. 10 oz.	After spawning, 1 lb. 14 oz.
	(2)	,, 2 ,, 10 ,,	,, 1 ,, 12 ,,
	(3)	, 2 ,, 12 ,,	,, 1 ,, 14 ,,
	(4)	,, 3 ,, 0 ,,	,, 2 ,, 4 ,,
	(5)	,, 3 ,, 0 ,,	,, 2 ,, 2 ,,

The average weight of these five females at this date is therefore 2 lb. 12·8 oz., while the average weight of spawn removed from them is 13·2 oz. This weight of spawn thus constitutes as much as 29·5 per cent of the average total weight, and amounts in one individual (No. 2) to one-third of the total weight of the fish. On June 19th, 1908, four of the salmon were weighed and measured as representing an average sample of the twelve that remained at the Laboratory. The figures obtained were:—

	Weight. lb.	oz.		Length. inches.
(1)	3	2	...	19
(2)	3	4	...	$19\frac{1}{2}$
(3)	4	0	...	$20\frac{1}{4}$
(4)	5	0	...	$22\frac{1}{2}$

It must, however, be mentioned that the weight given for the last fish, 5lb., is inconsistent with a subsequent test two months later, in which the heaviest fish weighed 4 lb. 8 oz. There is no ground for supposing that an error occurred in the reading, but it is difficult to understand such a loss of weight in the interval, and it is safer to omit these four weights in considering the average rate of growth.

It was subsequently decided by the Duke of Bedford that as little information was likely to be added by retaining the salmon any longer at the Laboratory they should be liberated. On August 20th, 1908, the remainder were therefore marked and turned out into the sea, outside the Plymouth Breakwater. Some of them were already showing signs of approaching maturity for the third time, and in one of them that died before being liberated the ovary was much developed. Including this last individual, the weight of these eleven fish at this date was as follows:—

	Weight. lb.	oz.		Length. inches.
(1)	2	4	...	17
(2)	2	8	...	19
(3)	3	1	...	19
(4)	3	8	...	19
(5)	3	7	...	20
(6)	4	0	...	21
(7)	4	0	...	21
(8)	4	1	...	21
(9)	4	1	...	21
(10)	4	3	...	21
(11)	4	8	...	22

giving an average weight of 3 lb. $9\frac{1}{2}$ oz., and an average length of 20 inches.

Summarizing the above data, the following show the averages of growth at intervals, during the period of about two years and a half, in which the salmon were kept at the Laboratory:—

Date.		Approx. Age.		Average Weight. lb.	oz.		Average Length. inches.
1906. Feb. to March	...	2 years	...	0	$4\frac{1}{2}$	...	9
„ Sept. 28th	...	$2\frac{7}{12}$ „	...	1	$8\frac{1}{2}$ (approx.)		16 (approx.)
„ Nov. 26th	...	$2\frac{3}{4}$ „	...	1	$8\frac{1}{2}$	...	—
1907. „ 15th	...	$3\frac{3}{4}$ „	...	2	12	...	—
1908. Aug. 20th	...	$4\frac{1}{2}$ „	...	3	$9\frac{1}{2}$	...	20

The average rates of growth per month, from the smolt stage in February and March, 1906, are therefore:—

For nine months to November 26th, 1906	. .	2·2 oz. per month.
„ twelve „ „ „ 15th, 1907	. .	1·6 „ „
„ nine „ „ August 20th, 1908	. .	1·5 „ „

It only remains to mention that the form which the salmon assumed was quite an abnormal one. The silvery colour of the smolts after entering sea water was not retained, but the dorsal region became dark and much spotted. This tendency increased till ultimately the greater part of the region above the lateral line was much darkened and the spots increased in size and in number, extending over the whole length of the body, and in places considerably below the lateral line, being especially large and prominent about the head and gill-covers. The accompanying figure (Plate XXIV.) illustrates these points in the female, weighing about 4 lb., which died on August 20th, 1908, the date on which the remainder of the salmon were liberated. The flesh of this fish was found to have no appearance of the normal "salmon" colour, but was of a pale brownish white.

Plate XXIV.

SALMON (*SALMO SALAR*).

To face p. 312.

On the Genus Cumanotus.

By

Sir Charles Eliot, K.C.M.G.

(See Eliot on *Coryphella beaumonti* in Notes on some British Nudibranchs, *Journ. Mar. Biol. Assoc.*, vol. vii., No. 3, June, 1906, pp. 361–3; and Nils Odhner on *Cumanotus laticeps* in Northern and Arctic Invertebrates, iii. *Opisthobranchia. Kngl. Svenska Vetenskapsakademiens Handlingar. Band* 41, No. 4, 1907, pp. 29, 80, and 101–2).

In describing (l.c.) *Coryphella beaumonti* as a new species, I pointed out that in many important characters it differs markedly from the other known *Coryphellæ*, and might be made the type of a new genus. But I did not create a new genus, thinking it might be well to examine further specimens, both of this animal and of allied forms, before deciding on its place in the classification. In the next year Odhner created (l.c.) the genus *Cumanotus*,* to which *Coryphella beaumonti* is certainly referable, and which is shown by his researches to be well characterized. It is allied to *Coryphella* inasmuch as it has unperfoliate rhinophores, tentacular angles to the foot, a triseriate radula and denticulate jaws; but it also possesses the following special characters: (1) The oral tentacles are very small and connected by a cutaneous fold which runs across the head; (2) there are several (at least, as many as three) rows of cerata in front of the rhinophores; (3) the verge is deeply grooved, and there is a bursa copulatrix, the entrance to which bears on its upper and lower margin a circular pad, armed on the periphery with twelve small cones terminating in hooks.

In the specimen which I dissected, the reproductive organs were much contracted, and I supposed these cones to be an armature on the male genitalia, such as is not uncommon in aeolids; but a dissection of more specimens, as well as an examination of the animals in life, has shown that Mr. Odhner is perfectly correct in describing the arrangement as two pads placed at the entrance of the bursa copulatrix. I have not seen the animals alive myself, but Mr. L. R. Crawshay, who observed their movements in the tanks of the Plymouth Laboratory, writes to me that: "Though in appearance the arrangement suggests

* He says it is from κῦμα, a wave, and νῶτον, back; but if so, would not *Cymanotus* be the more usual form?

that the hooked pads are associated with the ♂ rather than with the ♀ organ . . . at the same time, what was observed in the Laboratory points strongly to the conclusion that they are really ♀ clasping organs. If the organs of the one individual are called A (♂), B (♀), and of the other, X (♂), Y (♀), what was observed was as follows: The two individuals were placed right to right with the complete apparatus of both extended and approximating. The base of A (♂) was grasped laterally by an upward extension (i.e. presumably the pads) on both sides of Y (♀), and the base of X (♂) was similarly grasped by upward lateral extensions of B (♀). In each case a sort of peristaltic movement on the part of B (♀) and Y (♀) occurred. As the grasp of B (♀) and Y (♀) extensions relaxed, the flow of spermatozoa from X (♂) and A (♂) respectively was distinctly visible, while as the grasp of the extensions closed round the base of X (♂) and A (♂), the flow of spermatozoa was checked." As far as I am aware, a female clasping organ of this kind has not yet been recorded among Nudibranchs, but it is possible that in some other genera of aeolids its nature may have been misunderstood.

It is doubtful whether *Cumanotus beaumonti* and *Cumanotus laticeps* are specifically the same. The identity is not improbable, but Odhner's specimens (judging from the figures) had lost all the cerata. *Cumanotus beaumonti* is remarkable for having a short truncated body and extremely long snaky cerata, but when these have fallen off the Plymouth specimens look very like Odhner's figures, and have the margin of the foot similarly expanded. There may also be differences in the denticulation of the jaws and lateral teeth. But these are slight divergences, and hardly of specific value unless associated with others. Still, until a complete specimen of the Norwegian form has been examined it is safer not to unite the two species, and provisionally I think the genus may be tabulated as follows:—

Cumanotus, Odhner, 1907.

1. *C. beaumonti* (Eliot), 1906.
2. *C. laticeps*, Odhner, 1907.

If the species are united the name *beaumonti* has priority.

I hope to publish figures of the living *C. beaumonti* in a supplement to Alder and Hancock's *British Nudibranchiate Mollusca*, which will soon be issued by the Ray Society.

C. laticeps is known by four specimens obtained at Sörvær, in the extreme north of Norway, in 5–10 fathoms of water. *C. beaumonti* has been captured at Plymouth, twice in Barn Pool and on several occasions in Jennycliffe Bay, at a depth of 2–5 fathoms, and though far from common, appears to be a resident and not merely a visitor.

Note on a Hermaphrodite Cod (*Gadus morrhua*).

By

A. E. Hefford, B.Sc.,

Assistant Naturalist at the Plymouth Laboratory.

With one Figure in the Text.

On February 27th, the roe of a cod having a testicular portion attached was received at the Laboratory from Messrs. Moodys and Kelly, of Grimsby. It had been taken from a cod caught by a steam trawler fishing in Icelandic waters. Owing to the rough removal of the organs from the fish on the trawling ground, the genital ducts were missing and the region of their origin was ruptured, while the testis had been somewhat damaged in the course of its long journey to Plymouth.

Fig. 1 shows a drawing of the organs seen from the ventral side. The female element predominates, the ovaries appearing quite normal and functional, with unripe ova at a stage of development which suggests that spawning should occur in about two to four months. The left ovary is $6\frac{1}{2}$ inches long and the right one $6\frac{1}{4}$ inches—a practically symmetrical condition. The testicular portion is connected with the left ovary by a duct a quarter to half an inch long, enclosed by a continuation of the fibrous covering of the ovary, the point of connection being very near to the median line and about a quarter of an inch behind the anterior extremity of the median ovarian mass. The form of the testis is rather rosette-like and frilled, but much less lobulated than a normal testis. The length of the longest lobe of the rosette measured from the duct is about 3 inches. It is now rather broken, however, and the original length was probably a little greater.

Internally the testis duct is longitudinally ridged, one of these ridges widening into a valve-like flap near the small aperture which leads into the lumen of the ovary. The testis is in a well-developed but unripe condition. Owing to maceration in the course of transit—on the trawler it was kept in ice and then sent through the post to

Plymouth wrapped up in paper in a box—the tissue is not suitable for microscopic examination. It is probable, however, that the male organ would be functional, and that when ripe its products would pass to the exterior *via* the testis duct and the ovary. Owing to the ruptured condition of the right ovary in the region corresponding to the testis

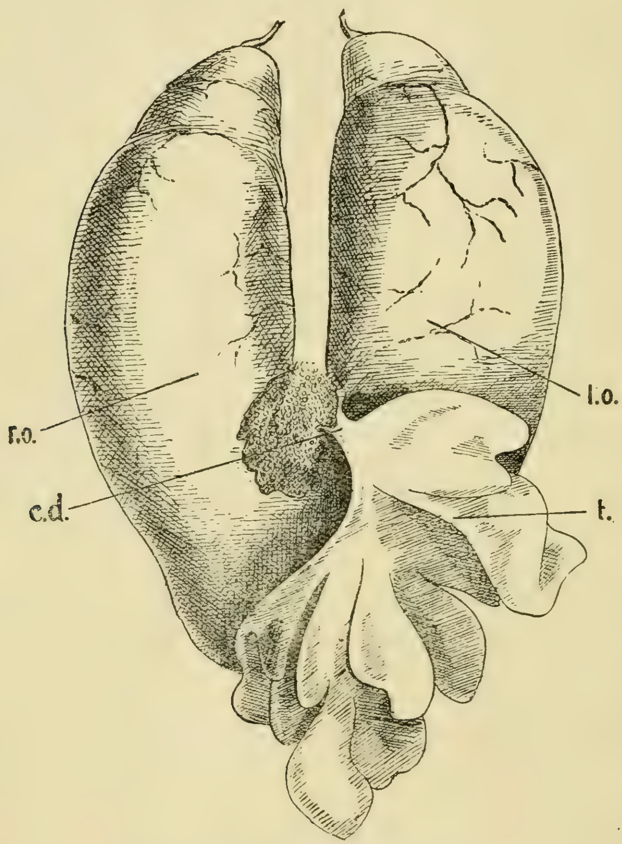


Fig. 1.—Hermaphrodite Gonad of Cod.

r.o., right ovary; l.o., left ovary; t., testis; c.d., testis duct.

duct attachment on the left, I am not able to say with absolute certainty that the above-mentioned is the only testicular part, though there is extremely little doubt but that the whole of the genitalia were removed from the fish, the ruptured portion being the result of tearing away the roe from its duct to the exterior.

Other examples of hermaphroditism in cod have been described by Howes,* Masterman,† Williamson,‡ etc.

Masterman gives a tabular list of eleven cases for comparison, including his own observation and those cited by Howes. In all these the ovarian organ preponderates. Great diversity is shown in the position of the testis, which may be single or in as many as three distinct and separately attached parts. In Williamson's two cases, one presents a perfectly symmetrical form with a small testis attached to the anterior end of each ovary, while the other is completely asymmetrical, the right gonad being an ovary and the left a testis, the two uniting in the anal region and having a common genital aperture. My specimen presents a further variation in the position of the testis. In the relatively large size of the testicular portion it is also peculiar.

* G. B. Howes, "Hermaphrodite Genitalia of the Codfish," etc. (*Journ. Linn. Soc.*, xxiii., p. 539).

† Masterman, "On Hermaphroditism in the Cod" (*Thirteenth Annual Report of the Fishery Board for Scotland*, Part III, for the year 1894, p. 297).

‡ Williamson, "On Two Cases of Hermaphroditism in the Cod" (*Twenty-fourth Annual Report of the Fishery Board for Scotland*, Part III, for the year 1905, p. 290).

Note on a Conger with Abnormal Gonad.

By

A. E. Hefford, B.Sc.

With one Figure in the Text.

Among a sample of seven small Conger, from 58 to 77 cm. in length, obtained from the Plymouth Fish Quay on 31st March, one was found with unsymmetrical reproductive organs. The other six were immature females with the normal pair of ovaries. The abnormal specimen has a right gonad quite similar to the ovaries of females at the same stage of maturity. It is bandlike in form, extending along the whole length of the abdominal cavity. The inner or left side is covered with smooth peritoneal epithelium (mesoarium). The greater part of the surface of the right (outer) side is raised into transverse lamellæ containing the as yet little-developed ova embedded in fat-tissue. For about one to two millimetres from its free edge, the organ consists of a strip of fat-tissue quite free from germinal cells, and there is a similarly constituted longitudinal fold—here and there divided into a subsidiary one—extending parallel to and about 2 mm. from the free edge and bordering the lamellated germinal area. The ovary is 17·5 cm. long, its greatest width 12 mm., and the widest part of the lamellated area is about 7 mm.

The left gonad is a sterile ovary, the transverse germinal ridges being quite absent. Along the line of attachment there is a narrow longitudinal ridge of fat-tissue, fairly well developed anteriorly, but becoming discontinuous towards the hinder end; then a narrow strip of bare peritoneal epithelium (the area which is normally covered with the egg-bearing lamellæ); and along the free edge are folds of fat-tissue similar to those occurring in the normal ovary.

I am indebted to Mr. J. T. Cunningham for his kindness in examining and giving his opinion upon this specimen.

It is interesting to note that this abnormal individual was the sixteenth Conger examined by me since March 14th with the object of

obtaining a male specimen; but up to this time only females had been found. The sizes ranged from 92 to 58 cm., ten of them being less than 76 cm. (2 ft. 6 inches) which is the limiting size given by Cun-

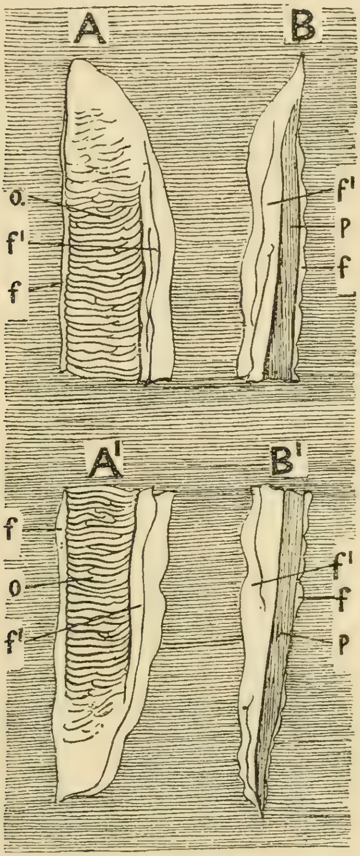


FIG. 1.—Abnormal Gonad of Conger.

A, anterior; A[1], posterior end of right (normal) gonad.
B, anterior; B[1], posterior end of left (abnormal) gonad.
o, egg-bearing lamellæ; f, fat-tissue along attachment edge of ovary; f[1], fat-tissue along the free edge of ovary.
p, peritoneal tissue (mesoarium).

ningham* for male Conger. Subsequently I have obtained two males, of 61 cm. (24 inches) and 50 cm. (20 inches) out of twenty trawl-caught Conger ranging from 77 to 50 cm. in length.

* J. T. Cunningham, "On the Reproduction and Development of the Conger" (*Journ. M.B.A.*, vol. ii, N.S., p. 31).

Marine Biological Association of the United Kingdom.

Report of the Council, 1907-8.

The Council and Officers.

Four ordinary and one special meetings of the Council have been held during the year, at which the average attendance has been ten.

All the meetings have been held in the rooms of the Royal Society at Burlington House, and the Council desire again to express their thanks to the Royal Society for the use of these rooms.

Committees of the Council have visited and inspected the Laboratories at Plymouth and Lowestoft, and have reported favourably on the condition of buildings and boats.

The Committee on Fishery-Investigations, appointed by the Treasury to inquire into the future conduct of such investigations in the United Kingdom, have visited the Plymouth and Lowestoft Laboratories and inspected the steam-trawler *Huxley*. Evidence was given before this Committee on behalf of the Association by Sir E. Ray Lankester, Dr. A. E. Shipley, Mr. J. A. Travers, Prof. G. C. Bourne, Dr. G. H. Fowler, Dr. H. R. Mill, Dr. E. J. Allen, Prof. W. Garstang, and Mr. D. J. Matthews.

The Laboratories.

A number of necessary repairs to the building and to the aquarium tanks at the Plymouth Laboratory have been carried out during the year, and a new centrifugal pump has been fitted for circulating the sea-water through the tanks. The main laboratory, the library and other portions of the building have been colour-washed.

The work of the Lowestoft Laboratory has been conducted in the same house as last year.

The Boats.

The steam-trawler *Huxley*, which has been for five years hired by the Association for the work of the English section of the International Investigations, has now been purchased upon favourable terms by the Marine Biological Association from her owner, Mr. G. P. Bidder.

Both the *Huxley* and the *Oithona*, the corresponding boat at Plymouth, were laid up during the winter months, and after undergoing full surveys were put into a condition of proper repair.

The sailing-boat *Anton-Dohrn* was used for the collecting work at Plymouth during the winter.

The Staff.

At the end of September, 1907, Dr. Walter Garstang resigned the post of Naturalist in Charge of Fishery Investigations, which he had occupied since 1897, in order to take up professorial duties at the University of Leeds. The Council did not feel justified in making a new appointment to his post, until H.M. Government had decided to continue the British share of the International Investigations for a further term of years. The Council desires to record its appreciation of the valuable help rendered to the work by Dr. Allen, the Director, in undertaking temporarily the difficult task of superintending both the Laboratories. Since Prof. Garstang's retirement Dr. Allen has resided chiefly at Lowestoft, and visited Plymouth when necessary. Mr. L. R. Crawshay has been promoted to be Assistant Director of the Plymouth Laboratory, and Mr. J. O. Borley to be Assistant Director of the Lowestoft Laboratory. Mr. A. E. Hefford has been transferred from Lowestoft to Plymouth, where he is specially engaged in the study of fishes and fishery questions. Mr. A. J. Mason-Jones, M.SC., of the University of Birmingham, has succeeded Mr. W. Bygrave as Assistant Naturalist for Plankton in connection with the International Investigations.

Mr. E. W. Nelson has been temporarily employed at Plymouth during the year.

Occupation of Tables.

The following Naturalists have occupied tables at the Plymouth Laboratory during the year:—

W. C. De Morgan, London (Crustacea).
J. C. Simpson, Cambridge (Echinodermata).
C. H. O'Donoghue, London (Hydrozoa).
A. J. Grove, Birmingham (Protozoa).
F. W. Gamble, D.SC., F.R.S., Manchester (Colour Physiology of Fishes).
G. W. Smith, B.A., Oxford (Sacculina).

F. J. Bridgeman, London (Development of Porifera and Elasmobranchii).
R. D. Laurie, M.A., Oxford (Crustacea. Biometrical Study).
E. T. Browne, B.A., London (Cœlenterata).
W. Bygrave, B.A., Cambridge (Plankton).
J. R. Davidson, Plymouth (Plankton Larvæ).
J. C. F. Fryer, Cambridge (General Zoology).
E. S. Goodrich, M.A., F.R.S., Oxford (Thymus of Fishes).
R. L. Robinson, London (General Zoology).
R. M. Richards, London (General Zoology).
Miss W. Coward, Manchester (General Zoology).
Miss H. L. M. Pixell, B.Sc., London (Ferments of Digestive Tract of Elasmobranchii).
Sir Charles Eliot, K.C.M.G., Sheffield (Nudibranchiata).
Miss A. Isgrove, B.Sc., Manchester (Eledone).
H. M. Fuchs, Brighton (General Zoology).
Mrs. O. A. Meritt Hawkes, M.Sc., Birmingham (Embryology and Nervous System of Elasmobranchii).
H. H. Bloomer, Birmingham (Psammobia).
G. H. Grosvenor, B.A., Oxford (General Zoology).

Twenty-five students attended a course of study in Marine Biology conducted at the Laboratory during the Easter vacation by Mr. G. H. Grosvenor.

The Library.

The thanks of the Association are due for the following books and current numbers of periodicals presented to the Library during the past year:—

Académie Imp. des Sciences de St. Pétersbourg. Bulletin.
American Museum of Natural History. Bulletin.
—— Memoirs.
—— Report.
American Microscopical Society. Transactions.
American Philosophical Society. Proceedings.
Armstrong College. Calendar.
Australian Museum. Memoirs.
—— Records.
—— Report.
Bergens Museum. Aarbog.
—— An Account of the Crustacea of Norway, etc.; by G. O. Sars.
Bernice Pauahi Bishop Museum, Honolulu. Occasional Papers.
—— Fauna Hawaiiensis.
Board of Agriculture and Fisheries. Annual Report of Proceedings under the Salmon and Freshwater Fisheries Acts.
—— Report of Proceedings of 16th Annual Meeting.
Boston Society of Natural History. Proceedings.
Bristol Naturalists Society. Proceedings.
British Association for the Advancement of Science. Report.
British Museum. National Antarctic Expedition, 1901–4. Natural History.
Brooklyn Institute of Arts and Sciences. Science Bulletin.
Brown University. Contributions from the Anatomical Laboratory.

Budgett Memorial Committee. The Work of John Samuel Budgett.
Bulletin Scientifique de la France et de la Belgique.
Cairo Zoological Gardens. Report.
—— Additions to the Menagerie.
The Cancer Research Fund. Scientific Reports on the Investigations.
Cardiff Incorporated Chamber of Commerce Report.
The Carnegie Institution. Publications.
College of Science, Tokyo. Journal.
College voor de Zeevisscherijen. Verslag van den Staat der Nederlandsche Zeevisscherijen.
Colombo Museum. Spolia Zeylanica.
The Commissioners of Fisheries, N.S. Wales. Report.
Conchological Society of Great Britain and Ireland. Journal of Conchology.
Conseil perm. internat. pour l'Exploration de la Mer. Bulletin des Résultats acquis pendant les Courses Périodiques.
—— Publications de Circonstance.
—— Rapports et Procès-Verbaux des Réunions.
Cuerpo de Ingenieros de Minas del Peru. Boletin.
Danish Biological Station. Report to the Board of Agriculture.
Kgl. Danske Videnskabernes Selskab. Oversigt.
—— Skrifter.
Dept. of Agriculture, etc., Ireland. Reports.
Dept. of Commerce and Labor, U.S.A. Report of the Commissioner of Fisheries.
Dept. of Fisheries, N.S. Wales. Additions to the Fish-Fauna of New South Wales. By D. G. Stead.
—— Note on a small Collection of Fishes from Suwarow Island. By D. G. Stead.
—— Preliminary Note on the Wafer (*Leptoplana australis*). By D. G. Stead.
Dept. of Marine and Fisheries, Canada. Annual Report.
Deutsche Zoologische Gesellschaft. Verhandlungen.
Deutscher Fischerei Verein. Zeitschrift für Fischerei.
Deutscher Seefischerei Verein. Mitteilungen.
Falmouth Observatory. Meteorological and Magnetic Reports.
La Feuille des Jeunes Naturalistes.
Field Museum of Natural History. Annual Report.
—— Publications.
Finnlandische Hydrographisch-Biologische Untersuchungen.
Fisheries Society of Japan. Journal.
Fishery Board of Scotland. Annual Report.
Fiskeri-Beretning, 1905–6.
Fiskerinäringen i Sverige, Åtgärder. 1906.
Flodevigens Udklaekningsanstalts. Bidrag. 1892–1907.
Government Museum, Madras. Report.
Hertfordshire Museum Report.
R. Irish Academy. Proceedings.
Kansas University. Science Bulletin.
Kommission zur wissenschaftlichen Untersuchung der Deutschen Meere, etc. Wissenschaftliche Meeresuntersuchungen.
Kommissionen for Havundersögelser, Copenhagen. Meddelelser, series Fiskeri, Hydrografi, Plankton.
—— Skrifter.

Kgl. Norske Videnskabernes Selskab. Skrifter.

Kgl. Vetenskaps Societeten, Upsala. Stadgar.

—— Bibliographia Linnaeana. By J. M. Hulth.

Laboratoire Biologique de St. Pétersbourg. Bulletin.

Lancashire and Western Sea Fisheries. Superintendent's Report.

—— Quarterly Report on the Scientific Work.

Liverpool Biological Society. Proceedings and Transactions.

Liverpool Marine Biology Committee. Marine Biological Station at Port Erin. Report.

Liverpool University Institute of Commercial Research in the Tropics. Quarterly Journal.

—— The Commercial Possibilities of West Africa. By Viscount Mountmorres.

Manchester Microscopical Society. Annual Report and Transactions.

Manchester University Biological Society. Publications.

Marine Biological Association of the West of Scotland. Report.

Marine Biological Laboratory, Woods Holl. Biological Bulletin.

Mededeelingen over Visscherij.

Meteorological Office. Monthly Pilot Charts, North Atlantic and Mediterranean.

—— Monthly Pilot Charts, Indian Ocean and Red Sea.

R. Microscopical Society. Journal.

Ministère de l'Instruction Publique, France. Nouvelles Archives des Missions Scientifiques.

Musée du Congo. Annales.

Musée d'Histoire Naturelle, Paris. Bulletin.

Musée Océanographique de Monaco. Bulletin.

Museo Nacional, Buenos Aires. Anales.

Museo Nacional, Montevideo. Anales.

Museum für Meereskunde, Berlin. Führer.

Museum of Comparative Zoology, Harvard College. Bulletin.

—— Memoirs.

—— Report.

—— Harvard University Museum : Its Origin and History. By A. Agassiz.

—— Louis Agassiz. 1896. By W. James.

Museum of the Royal College of Surgeons. Catalogue of Osteological Specimens.

—— Catalogue of Physiological Series.

The Museums Journal.

Natural History Society of New Brunswick. Bulletin

Naturforschende Gesellschaft in Basel. Verhandlungen.

Naturhistorischen Museum, Hamburg. Mitteilungen.

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—— Katalog der aus dem palaarktischen Faunengebiet beschriebenen Säugetiere.
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Cunningham, J. T. On *Kalpidorhynchus arenicolæ*, a new Gregarine, parasitic in *Arenicola ecaudata.*
Dahl, Knut. The Scales of the Herring as a means of determining Age, Growth, and Migration.
Darbishire, A. D. On the Direction of the Aqueous Current in the Spiracle of the Dogfish ; together with some Observations on the Respiratory Mechanism in other Elasmobranch Fishes.
—— Some Tables for illustrating Statistical Correlation.
—— Recent Advances in Animal Breeding and their Bearing on our Knowledge of Heredity.

Dendy, A., and Hindle, E. Some Additions to our Knowledge of the New Zealand Holothurians.

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Hickson, S. J. Obituary Notice of Sir Michael Foster.

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Walker, A. O. Amphipoda. National Antarctic Expedition.

Weber, S. E. Polygenesis in the Eggs of the Culicidæ.

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General Work at Plymouth Laboratory.

Several reports on the material collected by the *Huxley* from the north side of the Bay of Biscay in August, 1906, have been published in the Journal, whilst others are still in preparation.

Mr. Crawshay and Mr. Worth have published in the Journal (vol. viii., No. 2) detailed reports on the nature of the bottom deposits found in the English Channel between the Eddystone and the fifty-fathom line, as a result of the dredging operations carried out in 1906. The biological reports dealing with these dredgings are not yet complete.

A large number of hauls have been made in the Channel during the year with a Petersen young-fish trawl, which has proved very successful in capturing larval, post-larval and young stages of fishes. Mr. A. E. Hefford is engaged in the study of this material, and is also studying the different aspects of the fisheries in the south-western district.

Mr. G. E. Bullen has continued his study of the food of the mackerel and other migratory fishes, and has prepared a report on the subject which will soon be published in the Journal.

Mr. E. W. Nelson has continued a series of experiments, which had been commenced by Dr. E. J. Allen, on "pure cultures" of Planktonic Diatoms and Algæ, in connection with the rearing of pelagic larvæ of fish and invertebrata.

Mr. C. L. Walton was temporarily engaged at the Laboratory from October to January, devoting his time chiefly to the study of the local Actiniæ, and an account of some of his observations has been published in the last number of the Journal.

An exhibit of tow-nets, trawls, dredges, etc., is being shown by the Association in the Hall of Science at the Franco-British Exhibition.

The International Fishery Investigations.

The following is a summary of the work done, and of the conclusions arrived at by the scientific staff working under the direction of the Council.

Section I.—NORTH SEA WORK.

A. WORK OF THE S.S. "HUXLEY."

Trawling Investigations.—From June 1st, 1907, to the end of May, 1908, the *Huxley* made 9 voyages, in the course of which 176 hauls of the commercial trawls were made, together with 347 hauls of various smaller nets and other gear. The total number of voyages made by the *Huxley* from the commencement of the investigations to the present date is 99; the total number of hauls made with commercial trawls is 1254, that with smaller gear 1153.

In the spring of this year trawling investigations, which it is proposed to repeat at quarterly intervals throughout the year, were carried out at certain selected positions and along a line already trawled in the spring of 1905 and 1906 and the summer of 1905. In this work the ordinary commercial trawls, the Beam trawl covered with fine meshed netting as described in the last report, and various smaller nets, were used, the hauls being made as strictly comparable in time and place as is possible under the unavoidable difficulties of marine work.

DREDGING INVESTIGATIONS.—Extensive series of hauls with Dredge, Conical Dredge and Agassiz trawl were made in the months of June, July and August in the deep water west of the Dogger and on the rough ground between Flamborough Head and Lowestoft and west of 3° E. long. In April similar work was carried out on different grounds between 52° and 53° N. lat.

In voyages 98 and 99 a small trawl with very coarse canvas netting, specially designed for the capture of small fish and crustacea, has been used with success.

FISH MEASURED.—Over 75,000 fish were measured during the year. As in past years, the entire catch was measured on nearly all occasions. The details as to the number of plaice, haddock and other species are as follows:—

		PLAICE.	HADDOCK.	OTHERS.	TOTALS.
1902–7	Voyages 1–90	107,614	47,240	253,293 ...	408,147
1907–8	Voyages 91–98	32,350	1,273	41,954 ...	75,577
	TOTALS	139,964	48,513	295,247 ...	483,724

Measurements of plaice accompanied by observations on maturity were also carried out, both at sea on a Lowestoft fishing-smack and at the Lowestoft market. In this way 1810 plaice were dealt with at sea in January, while in the observations on the market, which were made almost daily in November and December and at intervals throughout the first quarter of 1908, 10,786 plaice were examined.

MARKING EXPERIMENTS.—During the past year 2159 plaice and 15 other fish have been marked and set free. Of the marked plaice, 1430 were transplanted from the Dutch and Danish coastal grounds to the southern shoals of the Dogger Bank in May, 1908, with a view of obtaining information as to their rate of growth in 1908–9.

The more noteworthy of the remaining experiments were directed towards ascertaining the movements of plaice in autumn in the deeper water bordering the Dogger Bank, and of the spent plaice which were leaving the spawning grounds in the southernmost portions of the North Sea in spring. With these objects 278 plaice were marked at various positions round the Dogger Bank in August, 1907, and 190 plaice, including spent females of 35–40 cm. in length, were marked near Smith's Knoll Light Vessel in March, 1908.

Of the plaice marked from June 1st, 1906, to May 31st, 1907, 387 or 18·7 % were returned before June 1st, 1908. Of the fish marked in the year 1905–6, 25·6 % were returned before June 1st, 1907. These percentages are only comparable in a rough sense, since the times elapsing between the various experiments and the 31st of May following do not necessarily correspond in the two years. The difference is, how-

ever, worthy of notice. It seems to be due to the small number of transplanted fish recovered, the returns from the Fisher Bank being particularly small. Nearly two-thirds of all the fish marked were taken to the Dogger Bank, Great Fisher Bank and Little Fisher Bank: the percentages of these recovered before June 1st, 1907, were 15·1 %, 10·1 % and 2·5 % respectively, while of the fish marked in the ordinary marking experiments 34·6 % were caught again.

The conditions under which they were captured being in some respects unfavourable, there is reason to think that the transplanted fish were not very strong; this, together with the differences of intensity of fishing in the areas covered by the work of the two years, probably accounts for the different rates of recapture. Of the 749 fish transplanted in April and May, 1907, to the Dogger Bank, 15 were recovered after an interval of 12 months, and show an average yearly growth of 11·1 cm. Four fish were recovered a year after liberation on the Great Fisher Bank, having increased in length by 5·0–10·7 cm. Only one fish of those set free on the Little Fisher Bank was recaptured after the same period; this had grown 4·6 cm.

During the year, 9 turbot, 3 cod and 3 latchets were also marked, and the following marked fish were returned: 33 thornback rays, 17 soles, 10 cod and 3 brill. Considering the small number of fish marked, and the fact that practically all were marked before June, 1907, the proportions of cod and thornbacks returned in the current year seem to indicate that the mark is fairly suitable for work with these fish. Of 295 soles marked in the year 1906–7 about 6 % were recaptured before June 1st, 1908.

Vitality Experiments.—The plaice caught in 14 hauls of the commercial trawl were examined with a view to the estimation of the proportion that would survive under various conditions of trawling, if returned to the sea either at once or after certain periods on deck. The number of plaice dealt with in these experiments is 16,163, each of which had to be examined separately.

Marked Coconuts.—In September, 1906, 859 coconuts were put overboard in the North Sea. 142 of these nuts have now been recovered. In many cases the wire by which the label is fastened to the nut is found to be much worn, indicating a considerable amount of motion at the sea bottom on which the nut rested.

B. LABORATORY WORK.

Maturity of Plaice.—During the past year the investigations with regard to the age and size of plaice at maturity in different parts of the North Sea and English Channel, and also those on the distribution of

spawning plaice, have been continued. The results show that, on an average, female plaice are first mature when at the end of their sixth year on the grounds around the Dogger Bank, at the end of their fifth year in the southern part of the North Sea, and at the end of their fourth year in the western part of the Channel. Males, on an average, mature a year earlier than the females.

There is evidence to show that spawning takes place particularly in the deep water off the Yorkshire coast and at the southern end of the North Sea, but not in the region of the Leman Banks or on the Dogger Bank. Spawning off Yorkshire appears to occur later than on the southern spawning ground.

The examination of 123 otoliths suggests that local and sexual differences are reflected in the otolith, owing to a diminution of growth at maturity. The data are not however considered to be as yet sufficient for the satisfactory substantiation of this conclusion.

The material for this research consists in observations on the size and maturity of 13,247 plaice, in 4,106 of which the age was determined from the otoliths.

OBSERVATIONS ON PLAICE IN THE BARENTS SEA.—By the kindness of Messrs. Hellyer, a member of the staff was enabled to make a voyage to the Barents Sea in a Hull trawler, in August last. In the course of this voyage 2,146 male and 2,365 female plaice were measured.

The "average size at first maturity," i.e. the length at which 50 % are mature, was found to be about 40 cm. for female plaice from the Barents Sea; which is the same as for those from the central grounds of the North Sea. Whereas, however, in the Barents Sea the great majority of the plaice caught on the voyage were considerably above this "average size at first maturity," and had therefore spawned once at least, the majority of plaice examined in the North Sea were below it, most of them not having spawned at all before being caught. The North Sea thus is in the condition which theoretically should result from the overfishing of such a plaice population as that of the Barents Sea.

The rate of growth of the Barents Sea plaice appears to be slow, possibly owing to the low temperature (about 2° F. above freezing point) which prevails.

There is some evidence that the plaice migrate towards Atlantic water for spawning purposes, as do those of Iceland.

An account of this voyage appears in the Journal of the Association, vol. viii., p. 71.

VITALITY OF TRAWL-CAUGHT PLAICE.—A report has been prepared

on the results of the experiments carried out on this matter by the *Huxley*. The fish tested were derived from 12 Otter- and 16 Beam-trawl hauls of different duration. The catches varied in nature and weight. Each catch was tested in sections, batches of fish being placed in tanks of circulating sea-water after various periods of exposure; the total number of such batches was 89.

Consideration of the data obtained leads to the conclusion that few of the small plaice captured in the process of commercial trawling would survive if returned to the sea immediately after they reached the deck; while if returned, as in practice they would be returned, after the fishermen had dealt with the marketable catch, the percentage surviving would be extremely small.

The Otter trawl is found to injure a far greater proportion of the fish than the Beam trawl, though probably the very long hauls of the latter which are quite commonly taken by the sailing vessels using these trawls would produce the same effect as the hauls with the Otter trawl. Long hauls, the presence of *Medusæ* in the net, hot sunshine during the time the fish are on deck and probably heavy catches are all detrimental to the fish.

MIGRATION OF COD.—A brief report on this subject has also been completed.

It is based on the 252 cod marked on the *Huxley* and the 42 recaptures recorded up to the date of writing. Most of the recaptures, constituting 13 % of the healthy fish liberated, took place within six months of liberation.

The fish below 60 cm. in length appear to have remained in water of depth similar to that in which they were first caught, and had not travelled far. Most of those which had moved some distance from the liberation point were recaptured south or west of it.

The number of these is however small. Fifteen cod which remained for more than three months at liberty showed an average rate of growth of 1·5 cm., but afforded no indications of different growth rates at different seasons.

FOOD OF FISHES.—Since the conclusion of the second report on this subject the stomachs of 2,040 fish, belonging to 24 species have been examined and their contents identified. The total number of fish subjected to examination during the investigations is 11,866, drawn from 39 species.

INVERTEBRATE FAUNA.—The preparation of a report on the distribution of invertebrates in the North Sea, based on the operations of the *Huxley*, is in progress. The report will deal with 2,168 hauls made before the end of 1907.

BOTTOM DEPOSITS.—During the year the collection of bottom samples has been increased by 161, and is now 549. All those collected before the end of 1907 have been classified by reference to type specimens and graded by the use of sieves with holes ranging from 15·0 to 0·5 mm. diameter. The percentage of silt has also been estimated in each case, and the shells present have been identified.

In certain typical samples the chief minerals have been determined. Elementary chemical examination of these samples is proceeding.

Taken as a whole the material shows that wide areas exist over which the condition of the bottom is exceedingly uniform, and that these areas are confined to the central and eastern parts of the North Sea: west of 2° E. long. the ground is extremely irregular and for the most part coarse in texture. The distribution of considerable quantities of the various grades of deposits on the offshore grounds can be defined with some confidence in the south part of the North Sea.

C. FISHERMEN'S RECORDS.

There has been no change in the method of carrying out the collection and examination of fishermen's records.

A report on the records of the catches of plaice and soles obtained from Lowestoft smacks has been completed. It deals with 4,929 hauls, made in the years 1903–6, and shows that the average catch of plaice per six hours' fishing, by the three boats whose records are considered, markedly declined during this period. The catch of soles also declined, though after 1905 the decrease was very small. No conclusion as to the cause of this general decline in the years considered has been reached.

The catches of turbot and brill have been treated in a similar manner, that of turbot showing a continuous decline, that of brill falling until 1905, and then rising; the numbers of these two species caught are not, however, great.

The treatment of the Grimsby records, obtained from steam-trawlers, is proceeding. 13,535 hauls made in the years 1904–7 have been tabulated by areas, and the monthly average catches of turbot, brill, and soles determined together with that of plaice for 1905.

SECTION II.—HYDROGRAPHIC AND PLANKTON WORK IN THE ENGLISH CHANNEL.

During the past twelve months the hydrographic investigations have been carried out according to the programme of recent years, and the quarterly cruises have been extended into the Irish Channel nearly as far north as the Smalls. A large number of samples of water have been received from outside sources, while the establishment of a regular weekly sailing between Plymouth and Brest by the G.W.Ry. Co. has

made it possible to obtain surface samples every fortnight on this line, so that a continual record can be kept of the surface changes over the whole of the English Channel.

During the month of August, 1907, salinities were, on the whole, somewhat low. At the south-west extremity of the area investigated the water was of the same composition from top to bottom, which is somewhat unusual at this season; to the north of this, however, at about sixty miles true south of the Scilly Islands, a distinct division into layers of different origin was found, and this condition could be traced in a northerly direction to the Smalls Lighthouse.

The November cruise showed that the waters of the Irish Channel were becoming more homogeneous, while in the western part of the English Channel a more pronounced division into layers of varying salinity had appeared. The investigations in the eastern area had to be considerably curtailed owing to continued bad weather.

During December, 1907, the surface conditions, as shown by samples received from liners and cross-channel steamers, were decidedly abnormal. Irregular patches of water of very high salinity appeared to the south-west, off the Cornish coast, while the salinity between Newhaven and Caen fell to below 34 parts per thousand. During January and February the high salinity water advanced eastward, and there is reason to suppose that in April it had reached the line joining the Isle of Wight and Havre. The low salinities found between Newhaven and Caen during December were not found in January, and it is probable that they were due to a thin surface layer which would be quickly obliterated by mixing.

During the year samples of Plankton were taken in the usual manner on the four quarterly cruises, and also at regular intervals at Plymouth, and at light-vessels on the English and Irish coasts. Samples were also taken each week, midway between Plymouth and the Channel Islands, from the s.s. *Devonia*. The records of species taken on the quarterly cruises are published in the Bulletin of the International Council.

The samples taken during the August cruise at one station in the Bristol Channel (E. 30) contained pieces of a peculiar Siphonophore, apparently *Lychnagalma*, Haeckel. This was also found off Ushant in November. The appearance of two small Protozoans, *Dictyocysta elegans*, Ehrb., and *Dictyocysta mitra*, Haeck., at the Western Stations in November are of interest in connection with the peculiar hydrographic conditions of the English Channel and the North Sea during that month. These organisms, according to Brandt, have a distinctly Atlantic distribution.

Published Memoirs.

The following papers, either wholly or in part the outcome of work done at the Laboratory, have been published elsewhere than in the Journal of the Association :—

COTTON, A. D.—*Some British Species of Phaeophyceæ.* Journal of Botany, vol. 45, 1907, pp. 368–373.

DARBISHIRE, A. D.—*On the Direction of the Aqueous Current in the Spiracle of the Dogfish ; together with some Observations on the Respiratory Mechanism in other Elasmobranch Fishes.* Linn. Soc. Journ. Zool., vol. 30, 1907, pp. 86–94.

HODGSON, T. V.—*Pycnogonida.* National Antarctic Expedition. Natural History, 1907.

HODGSON, T. V.—*The Pycnogonida of the Scottish National Antarctic Expedition.* Trans. Roy. Soc., Edinburgh, vol. 46, Part I., 1908.

MACBRIDE, E. W.—*Some Points in the Development of Ophiothrix fragilis.* Proc. Roy. Soc., Ser. B., vol. 79, pp. 440–445.

MACBRIDE, E. W.—*The Development of Ophiothrix fragilis.* Quart. Journ. Micr. Sci., vol. 51, 1907, pp. 557–606.

SMITH, GEOFFREY.—*The fixation of the Cypris Larva of Sacculina carcini (Thompson) upon its Host, Carcinus maenas.* Quart. Jour. Micr. Sci., vol. 51, 1907, pp. 625–632.

WOODLAND, W.—*Studies in Spicule Formation,* VII. *The Scleroblastic development of the Plate-and-Anchor Spicules of Synapta, and the Wheel Spicules of the Auricularia Larva.* Quart. Journ. Micr. Sci., vol. 51, pp. 483–509.

Donations and Receipts.

The receipts for the year for the ordinary work of the Association include the grants from His Majesty's Treasury (£1000) and the Worshipful Company of Fishmongers (£400), Special Donations (£40), Annual Subscriptions (£96), Rent of Tables in the Laboratory (£85), Sale of Specimens (£400), Admission to Tank Room (£134).

Vice-Presidents, Officers, and Council.

The following is the list of gentlemen proposed by the Council for election for the year 1908–9 :—

President.

Sir RAY LANKESTER, K.C.B., LL.D., F.R.S.

Vice-Presidents.

The Duke of ABERCORN, K.G., C.B.
The Duke of BEDFORD, K.G.
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Dr. *Statement of Receipts and Payments for*

		£ s. d.	£ s. d.
To Current Income :—			
H.M. Treasury		1,000 0 0	
Fishmongers' Company		400 0 0	
Annual Subscriptions		96 11 0	
Rent of Tables		85 2 0	1,581 13 0
„ Extraordinary Receipts :—			
Donations :—			
E. T. Browne, Esq.	£5 0 0		
Per Dr. A. E. Shipley	35 0 0	40 0 0	
Composition Fee		15 15 0	
Hire of Steam Boats :—			
S.S. *Huxley*	£600 0 0		
S.S. *Oithona*	50 0 0	650 0 0	705 15 0
„ Balance :—			
Loan from Bank		700 0 0	
Less :—			
Cash at Bank	£437 5 7		
Cash in hand	18 19 11	456 5 6	243 14 6
Note.—This balance is apportioned as follows :—			
General Account, overdrawn		396 15 10	
Less Repairs and Renewals Account in credit		153 1 4	
		£243 14 6	
			£2,531 2 6

Examined and found correct,

(Signed) N. E. Waterhouse, A.C.A. L. W. Byrne.
Hugh Robert Mill.

24th June, 1908.

the *Year ending* 31*st May*, 1908. **Cr.**

		£ s. d.	£ s. d.
By Balance from last year, viz. :—			
Loan from Bank		400 0 0	
Less Cash at Bank	£69 1 0		
Cash in hand	20 11 4	89 12 4	310 7 8
,, Current Expenditure :—			
Salaries and Wages—			
Director		200 0 0	
Assistant Director		206 13 9	
Naturalist		139 11 8	
Salaries and Wages		687 13 0	1,233 18 5
Travelling Expenses			53 10 2
Library			104 4 1
Journal		50 15 6	
Less Sales of Journal		10 2 8	40 12 10
Buildings and Public Tank Room—			
Gas, Water, and Coal		122 7 9	
Stocking Tanks, Feeding, etc.		42 15 2	
Maintenance and Renewals		110 19 2	
Rent of Land, Rates, Taxes, and Insurance		35 12 1	
		311 14 2	
Less Admission to Tank Room		134 10 11	177 3 3
Laboratory, Boats, and Sundry Expenses—			
Stationery, Office Expenses, Printing, etc.		128 2 4	
Glass, Chemicals, and Apparatus	£151 15 1		
Less Sales	52 9 9	99 5 4	
Purchase of Specimens		56 2 8	
Maintenance and Renewal of Boats, Nets, Gear, etc.	£253 3 5		
Less Sales	5 9 5	247 14 0	
Insurance of Steamers—			
S.S. *Huxley* (half-year)	82 19 1		
S.S. *Oithona*	25 5 5	108 4 6	
Coal and Water for Steamers		130 19 6	
		770 8 4	
Less Sales of Specimens, etc.		400 10 6	369 17 10
Bank Interest			12 14 5
,, Extraordinary Expenditure :—			
On account of purchase of S.S. *Huxley*, including expenses of Vendor reimbursed by Agreement (the balance of the purchase price is secured by a Mortgage of the vessel repayable by annual instalments)			228 13 10
			£2,531 2 6

*

Marine Biological Association of the United Kingdom.

LIST

OF

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1st OCTOBER, 1908.

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C. signifies that he has paid a Composition Fee of Fifteen Guineas in lieu of Annual Subscription.

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*1908 Calman, Dr. W. T., *British Museum (Natural History), Cromwell Road, S.W.*.. Ann.
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A TREATISE ON THE COMMON SOLE.

BY

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Late Fellow of University College, Oxford; Naturalist to the Association.

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THE NATURAL HISTORY OF THE MARKETABLE MARINE FISHES OF THE BRITISH ISLANDS.

Prepared expressly for the use of those interested in the Sea-fishing Industries,

BY

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With Preface by

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PROFESSOR OF COMPARATIVE ANATOMY IN THE UNIVERSITY OF OXFORD.

Notes on the Littoral Polychæta of Torquay (Part II.).

By

Major E. V. Elwes.

Phyllodocidæ.

It cannot be said that all the species of the Phyllodocidæ have yet been satisfactorily defined, much difference of opinion existing as to the separation of varieties and species. In the accompanying key the nomenclature of Professor McIntosh has been followed, but those Annelids, which are classed by him as varieties, but which have been hitherto generally accepted as distinct species, are shown separately. The true specific value of the arrangement and nature of the papillæ on the proboscis can only be settled by the examination of numerous individuals from various localities; in the meantime it appears best to consider Annelids differing in these particulars as at least varieties worthy of a name.

Eulalia viridis, O. F. Müller. *McIntosh, Mon. Brit. Ann.*, vol. ii., p. 55.

The variety of *E. viridis*, most commonly found at Torquay, is coloured an uniform dark green, the cirri being rather lighter in colour. It is particularly abundant where the limestone rocks have been much eaten away from about half-tide mark downwards. It appears to like crawling about the damp rocks out of the water when the tide is low, and does not hesitate to leave the water when placed in a shallow vessel. The terminal papillæ of the proboscis numbered fourteen in all the individuals examined, like those found by de St. Joseph at Dinard; but the whole of the extended proboscis was covered with papillæ.

The variety *ornata* of de St. Joseph is fairly common, but does not appear to extend above the Laminarian zone. There appears to be very little doubt that this is the *P. griffithsii* of Johnstone. His specimens were obtained from Torbay, and there does not appear to be any species of *Eulalia* found there to which the description could apply.

The number of segments per inch of length mentioned by Johnstone applies much better to *ornata* than to *E. nebulosa*, Montagu.

The variety *aurea* of Gravier is also found at Torquay in the same localities as *ornata.* The dorsal cirri are distinctly less pointed, and the breadth of the segments greater in proportion to the length than in the case of the other varieties.

EULALIA NEBULOSA, Montagu = *E. punctifera*, Grube. *McIntosh*, *Mon. Brit. Ann.*, vol. ii., p. 53.

One specimen only from Corbyn's Head. Colour dull green rather than yellowish or red; some of the dorsal cirri heavily marked with dark colouring matter. The much longer upper limb of the bifid setigerous process of the foot is very characteristic of this species.

EUMIDA SANGUINEA, Œrsted = *E. pallida*, Grube. *McIntosh*, *Mon. Brit. Ann.*, vol. ii., p. 66.

The real distinction between the genera *Eulalia* and *Eumida*, as defined by Malmgren and McIntosh, is that in *Eulalia* the first pair of tentacular cirri are attached to a segment divided from the head by a constriction visible at least on the ventral side, while in *Eumida* the first pair of tentacular cirri are apparently attached to the head, the first segment being soldered to the head. Such a distinction is, however, unsatisfactory, because the visibility of a dividing line between the segment and head depends so much on the method of preparation of the specimen. The only British species is, however, easily recognised as a rule by the peculiar white markings, which look as if they had been painted on with Chinese white. It is common amongst the Laminaria roots at Torquay. Most of the specimens are coloured a pale brown, but one or two were found with a decided red tinge in the posterior part of the body.

The proboscis is covered with very small papillæ, which almost or entirely disappear in preparations, for which reason the smoothness of the proboscis as a generic distinction is also objectionable. Some of the individuals had black patches in the intestines like those described by Gravier in his *Eumida communis. Bull. Sc. Fr. Belg.*, t. xxxix., p. 18.

PHYLLODOCE MACULATA, Johnstone. *McIntosh*, *Mon. Brit. Ann.*, vol. ii., p. 89.

This is the only species of *Phyllodoce* which is at all common between tide marks at Torquay. It is found amongst rocks and weeds, and also in the sand. On one occasion sixteen individuals were found

in a whelk shell containing the decaying remains of a hermit crab.

The Torquay species agree well with the beautiful coloured drawing given in the *Mon. Brit. Ann.*

One specimen was found in a limestone pool which differed considerably from the type : the general colour much greener, the dorsal cirri larger in proportion and without spots, the distance between the feet greater. The number of the rows of papillæ on the proboscis could not be observed. Possibly this is the *Phyllodoce maculata* of Œrsted.

PHYLLODOCE LAMELLIGERA, Gmelin. *McIntosh, Mon. Brit. Ann.*, vol. ii., p. 76.

One light-coloured individual under a stone at Hope's Nose, and another of the normal colouring at Meadfoot.

Papillæ of the proboscis could not be observed.

PHYLLODOCE PARETTI, De Blainville. *McIntosh, Mon. Brit. Ann.*, vol. ii., p. 76.

The head and about twenty segments of one from Corbyn's Head. The specimen, mounted in weak Formalin solution, retained its beautiful colouring for some weeks, then changed gradually to a reddish brown.

Gosse, in *The Aquarium*, second edition, p. 243, describes an example of this species from Torbay.

ETEONE PICTA, De Quatrefages. *McIntosh, Mon. Brit. Ann.*, p. 100.

Small ones, about 25 mm. in length, are not uncommon amongst Laminaria roots. The pattern of the colouring agrees with that described by McIntosh, but the anal cirri are quite differently shaped to those in Pl. XLV, Fig. 3, of the Monograph, being ovate, exactly like those figured by Gravier, *Bull. Sc. Fr. Belg.*, Pl. XVI, Fig. 14.

NOTOPHYLLUM FOLIOSUM, Sars = *alatum*, Langerhans. *McIntosh, Mon. Brit. Ann.*

One from Livermead. The dorsal cirri appear to be much more deciduous than the ventral. Colouring like that described by McIntosh for specimens kept some time in confinement, namely, brownish green without the red iridescence.

Nepthydidæ.

NEPTHYS HOMBERGII, Lamark. *McIntosh, Mon. Brit. Ann.*, p. 17.

Moderate-sized examples of this species, about 90 mm. in length, are common in the sand at Tor Abbey Sands and Livermead. They were

also found in rather dirty, muddy sand in the inner harbour of Torquay. The posterior lamina of the ventral branch of the foot is more pronouncedly directed upwards and more truncate than is shown in any of the figures given in the monograph.

NEPTHYS CIRROSA, Ehlers. *McIntosh, Mon. Brit. Ann.*, vol. ii., p. 36. In clean sand in company with *N. Hombergii*, but not quite so numerous. It may be distinguished at once from *N. Hombergii* by its comparatively narrow width and the light colour of the bristles.

McIntosh says (p. 38) that de St. Joseph distinguishes this species by the larger size of the branchiæ. But it is not the branchiæ themselves, but the "cirre branchial" (called by McIntosh "the dorsal cirrus at the base of the branchia") which de St. Joseph says becomes larger and larger, until, for about the thirty last segments, it is almost longer than the branchiæ. See *Ann. Sc. Nat.*, *8th series*, xvii., p. 21.

Hesionidæ.

CASTALIA FUSCA, Johnston = *Kefersteinia cirrata*, Kef. *McIntosh, Mon. Brit. Ann.*, vol. ii., p. 127.

Common under stones, especially at Meadfoot; also in Laminaria roots. It is an extremely brittle species which, like other very brittle annelids, is best lifted up with a soft camel-hair brush.

MAGALIA PERAMATA, Mar. and Bobr. *McIntosh, Mon. Brit. Ann.*, vol. ii., p. 136.

Common amongst Laminaria roots.

Nereidæ.

MICRONEREIS VARIEGATA, Clpd. *Claparède, Beob. über anat. wirbel thiere, etc.*, 1863, p. 57 and Pl. XI, Figs. 56–7; and *Glanures parmi les Ann. de Port Vendres*, p. 122, Pl. XIII, Fig. 4a.

This little aberrant member of the Nereidæ is not recorded in the "Fauna of Plymouth." Four or five individuals were found amongst red algæ and Lithothamnion from the rocks between Oddicombe and Babbicombe beaches.

The length is 4 mm., number of segments 21. The head, which is rounded in front, has no tentacles or palps. There are four eyes, the lateral pair close together, the posterior pair close to the margin of the head; the first pair have conspicuous crystalline lenses. There are four pairs of tentacular cirri, the front pairs situated on the front edge of the buccal segment low down; the posterior pairs, which are inserted higher up, are slightly longer than the other. The tentacular cirri are

fusiform and are tinged with yellow. The body is coloured purple. The jaws are about twice as long as broad, the number of teeth in each jaw five. There are no denticles. The first pair of feet, which are uniramous, are attached to the buccal segment. The second pair are also uniramous, but all the other feet are deeply bifid.

There are about twenty bristles in each foot, the terminal pieces of which are straight and narrow; they are much longer in proportion to their length than those shown in Claparède's drawing. Bristles and spines are colourless. The drawing given by Claparède is quite accurate for an individual drawn under compression, but the feet and cirri as shown there are much flattened out.

LEPTONEREIS VAILLANTI. *de St. Joseph, Ann. des Sc. Nat. Zool.*, vol. v., 1888, p. 246.

One imperfect male Heteronereid form of this species was found in the month of February at Oddicombe. The posterior of the three regions into which the body is divided was absent, but the remaining segments agreed with the description and figures given by de St. Joseph. It is not recorded in the "Fauna of Plymouth."

NEREILEPAS FUCATA, Savigny. *McIntosh, Mon. Brit. Ann.*, vol. ii., Pl. LXI, Figs. 6 and 6a.

This is not strictly a littoral species, but may be sometimes found in whelk shells thrown up on the shore. One lived for about six months in a small aquarium in a broken whelk shell, but without any hermit crab. It usually had the head and about ten or twelve segments of the body protruding from the shell; this part of the body being curved and continually waved backwards and forwards, giving the worm a most curious resemblance to a cobra.

NEREIS PELAGICA, L. *McIntosh, Mon. Brit. Ann.*, vol. ii., Pl. LX, Figs. 6 and 6a.

This Nereis is extremely common in the roots of the Laminaria, nearly every root containing one or two. Several of the Heteronereid form were found in the same situation in January and February, 1907, on Oddicombe beach. They measured about 30 mm. in length.

NEREIS DUMERILII, Aud. and Ed. *McIntosh, Mon. Brit. Ann.*, vol. ii., Pl. LX, Figs. 10 to 10c.

Small individuals, 20 to 30 mm. in length, are very common amongst lagæ from rock pools and the Torquay harbour.

NEREIS IRRORATA, Mgrn. *McIntosh,* vol. ii., Pl. L, Fig. 17; and Pl. LX, Fig. 8.

Occasionally under stones at Petit Tor Bay and Babbicombe beach; also amongst roots of Zostera at Corbyn's Head.

The glands in the feet are very conspicuous in this species, both when living and preserved.

NEREIS CULTRIFERA, Grube. *McIntosh. Mon. Brit. Ann.,* vol. ii., Pl. LX.

Under stones, not very common, on the edge of the submerged forest at Tor Abbey Sands.

KEY TO THE GENERA OF PHYLLODOCIDÆ FOUND ON THE FRENCH AND ENGLISH COASTS OF THE CHANNEL.

Four tentacles	Two pairs of tentacular cirri		ETEONE, Savigny.
	Three pairs of tentacular cirri		MYSTIDES, Théel.
	Four pairs of tentacular cirri		PHYLLODOCE, Savigny.
Five tentacles	Four pairs of tentacular cirri	foot uniramous (one spine)	EULALIA, Œrsted (including EUMIDA and PTEROCIRRUS).
		foot biramous (two spines)	NOTOPHYLLUM, Œrsted.

KEY TO THE SPECIES OF PHYLLODOCIDÆ FOUND ON THE FRENCH AND ENGLISH COASTS OF THE CHANNEL.

Genus ETEONE.

Head as broad or broader than long	Dorsum spotted with red or brown	A deep notch between the head and first segment on each side. Dorsal cirri semiorbicular. Length, 40 mm.	**incisa*, de St. Joseph.
		Without a deep notch as above described. Dorsal cirri broadly lanceolate. Length, 75 mm.	*picta*, Qftg.
		No spots; colour white. Dorsal cirri obliquely cordate. Length, 80 mm.	**foliosa*, Qftg.
Head longer than broad		Dorsal cirri obliquely ovate. Length, 40 mm.	*pusilla*, Œrsted.

Genus MYSTIDES.

One pair of tentacular cirri on each of the first three segments. Length, 20 mm.	(*Protomystides*) **bidentata*, Lang.
A pair of tentacular cirri on the first segment, two pair on the second segment, the posterior pair with a leaf-like appendage. Length, 10 mm.	(*Mesomistides*) **limbata*, de St. Joseph.

* Not recorded from the British area.

Genus Phyllodoce.

Median dorsal cirri suborbicular		Colour brown. On each side of the proboscis two rows of large lanceolate papillæ in anterior part, and three rows of small papillæ at the base. Terminal papillæ, 20		**macropapillosa*, de St. Joseph.
Median dorsal cirri subrectangular		Colour greenish yellow with a brown spot formed of transverse lines on each segment, and usually a spot on each dorsal cirrus. Width of body without feet, 1 mm. Length, 80 mm. Terminal papillæ, 17	Six rows of papillæ on each side of base of proboscis	*maculata*, Johnst.
			Four rows of papillæ	*maculata*, Œrsted = *citrina*, Malmgren.
		Dorsal cirri greyish green, each segment marked with blue and brown transverse lines. Ventral cirri with a nipple-like tip. Proboscis with six rows of tubercles on front part of proboscis and six rows of papillæ on each side of base. Terminal papillæ, 17. Width of body without feet, 3 mm. Length, 180 mm.		*groenlandica*, Œrsted = *mucosa*, Malmgren.
		Colour reddish, with three dark spots on each segment. Six rows of papillæ on each side of proboscis at base. Terminal papillæ, 16. Width, 1·5 mm. Length, 30 mm.		**pulchella*, Malmgren.
Median dorsal cirri cordate or elongate ovate.	Longest tentacular cirri not twice as long as anterior dorsal cirri	Tentacles and tentacular cirri fusiform. Dorsal cirri bright yellow and green. Width, 4 to 5 mm. Length, 300 mm.		*Paretti*, De Blainvill = *splendens*, de St. Joseph.
		Dorsal cirri green spotted with brown; bases of anal cirri, swollen; eyes very large. Thirty-six rows of papillæ on proboscis. Width, 1 mm. Length, 30 mm.		**macropthalma*, Schmarda.
		Dorsal cirri red. Base of proboscis covered with papillæ. Terminal papillæ, 8. Width, 1 mm. Length, 15 to 100 mm.		*rubiginosa*, de St. Joseph.
	Longest tentacular cirri several times longer than the anterior dorsal cirri	Dorsal cirri, dull green; body, iridescent blue or green. Width without feet, 3 to 4 mm. Length, 160 to 750 mm.	Base of proboscis with six rows of papillæ on each side	*lamelligera*, Gmelin.
			Base covered with papillæ	var. *laminosa*, Savigny.
		Colour pale, with transverse brown or blue lines on each segment. Front part of proboscis with six longitudinal rows of red tubercles, then six rows of large papillæ, each row of three large papillæ followed by numerous rows of small papillæ. Terminal papillæ, 16. Width, 4 mm. Length, 300 mm.		**papulosa*, de St. Joseph.

* Not recorded from the British area.

Genus Eulalia.

Dorsal cirri lanceolate tapering to a point.	Ventral cirri of the second pair of tentacular cirri forming a long lanceolate foliaceous process = subgenus Pterocirrus.	Brown or dull green. Terminal papillæ, 48. Length, 50 mm.	*macroceros*, Grube.
		Pinkish grey. Terminal papillæ, 24. Length, 7 mm.	* *limbata*, Clpd.
	Ventral cirri of second pair of tentacular cirri not foliaceous	Green with a brown spot on each segment except the first. Proboscis without lateral papillæ. Terminal papillæ, 8. Length, 8 mm.	* *parva*, de St. Joseph.
		Green. Terminal papillæ, 14 to 21. Length, 80 mm.	*viridis*, L.
		Yellow, with a dark spot on the middle of each segment and two parallel bars on each side of the segment. Terminal papillæ, 18. Length, 60 mm.	*viridis*, var. *ornata*, de St. Joseph.
		Yellow, with two longitudinal violet lines on each side of the central line, and a dark line on each side of the segment. Terminal papillæ, 20. Length, 80 mm.	*viridis*, var. *aurea*, Gravier.
		Green, with a dark line broken into three parts on the centre of each segment. Terminal papillæ, 8. Length, 15 mm.	* *trilineata*, de St. Joseph.
		First and second segments uniform brown, remaining segments spotted. Unpaired tentacle half-way between the eyes and part of head. Terminal papillæ, 14. Length, 30 mm.	* *venusta*, de St. Joseph.

* Not recorded from the British area.

Genus Eulalia—*continued.*

Dorsal cirri cordate.	Unpaired tentacle in line with or very little in front of the eyes	Pale brown. First segment and some of the others marked with a white bar like Chinese white. Length, 30 to 60 mm.	(*Eumida*) *sanguinea*, Œrsted = *pallida*, Clpd.
		Body dull brown, with red dorsal cirri. Length, 14 mm.	*rubiginosa*, de St. Joseph.
		Green, with two brown spots on the head in front of the eyes. Upper limb of setigerous process much longer than the lower. Length, 150 mm.	*nebulosa*, Montagu = *punctifera*, Grube.
		Brilliant yellow and green, brown spots on dorsal and ventral cirri. Length, 150 mm.	* *splendens*, de St Joseph.
	Unpaired tentacle half-way between eyes and front of head	Clear brown. Length, 20 to 30 mm.	* *fuscescens*, de St. Joseph.
	Unpaired tentacle on the posterior edge of the head	Greyish brown, covered with fine spots. Length, 30 mm.	(*Eumida*) * *sanguinea*, Œrsted, var. *communis*, Gravier.
Dorsal cirri oval elongate, pointed		Straw-coloured with a dark line along each side at the base of the feet. Length, 40 to 80 mm.	*bilineata*, Johnston.
		Brownish, with a green longitudinal line in the middle of the back. Terminal papillæ of proboscis, 28. Length of dorsal cirri, 0·1 mm. Length, 12 mm.	* *pusilla*, Œrsted.
		Three conspicuous green or black spots on the back of each segment. Terminal papillæ, 14. Length, 100 mm.	*tripunctata*, McIntosh = *Claparedii*, de St. Joseph.

Genus Notophyllum.

Head furnished posteriorly with a flap on each side. Dorsal cirri uniform	*foliosum*, Sars = *alatum*, Langh.

* Not recorded from the British area.

KEY TO THE NEREIDÆ OF THE FRENCH AND ENGLISH COASTS OF THE CHANNEL.

- No denticles (paragnaths) on proboscis.
  - Buccal segment with feet and bristles. No palps or tentacles. Bristles all of one kind. Length, 4 to 6 mm. . . . . . *Micronereis variegata*, Clpd.
  - Buccal segment without feet. Head rounded; conspicuous glands in feet. More than one kind of bristle. Length, 30 mm. . . . . . *Leptonereis Vaillanti*, de St. Joseph.
- Denticles horny, not joined together, all conical.
  - Denticles only present on lower half of proboscis in exclusion, and inconspicuous. Very long mud-dwelling worm. Length, 400 mm. . . . . . *Eunereis longissima*, Johnston.
  - Denticles present in upper part of proboscis in exclusion.
    - Lower median dorsal group of denticles present. Upper lobe of notopodium with a leaf-like process. Large green worm. Length, 400 mm. . . . . *Nereis (Alitta) virens*, Sars.
    - Lower median dorsal group of denticles absent.
      - No hump at base of dorsal cirri in anterior part of body.
        - No conspicuous glands in feet.
          - Head longer than broad. Dorsal cirri longer than feet. Length, 80 mm. . . . . . *Nereis pelagica*, L.
          - Head broader than long. Dorsal cirri not longer than feet. Denticles very small. Front part of dorsal surface fawn-coloured in spirit. Length, 88 mm. . . *Nereis (Hediste) diversicolor*, O. F. Müller.
        - Glands in feet conspicuous.
          - Upper lobe of notopodium very long and cirrus-like in posterior portion of body. Length, 150 mm. . . *Nereis (Praxithea) irrorata*, Malmgren.
      - Hump at base of dorsal cirrus.
        - Two white bands on dorsum. Commensal of hermit crab. Length, 150 mm. . . . . . *Nereis (Nereilepas) fucata*, Savigny.

KEY TO THE NEREIDÆ OF THE FRENCH AND ENGLISH COASTS OF THE CHANNEL—*continued.*

Denticles horny, not joined together, some conical, others oblong .	Upper part of notopodium much enlarged in posterior portion of body.	Notopodium with three lobes. Length, 40 to 70 mm. .	*Nereis Marionii*, Aud. and Ed.
	Upper branch of notopodium not enlarged .	Broad worm. Denticles on ventral surface of lower proboscis arranged in two rows at regular intervals. Length, 170 to 200 mm.	*Nereis cultrifera*, Grube.
		Denticles as above irregularly arranged in two rows. Dorsal cirri posteriorly longer than the foot. Length, 40 to 70 mm.	*Nereis Floridana*, Ehlers.
Denticles horny, in some groups at least very small, very close together, and arranged in comb-like rows . .	Tentacular cirri very long, reaching fifteenth segment . . . . Conspicuous glands in notopodium; body often spotted with purple. Length, 20 to 70 mm.		*Nereis Dumerilli*, Aud. and Ed.

NOTE.—The main divisions of this key are taken from the table given by Baron de St. Joseph, *Ann. des Sc. Nat. Zool.*, series 8 T. V., 1898.

The Mollusca collected by the "Huxley" from the North Side of the Bay of Biscay, in August, 1906.

By

Alexander Reynell.

THIS paper deals with the Mollusca collected on the cruise of the s.s. *Huxley* to the north side of the Bay of Biscay in August, 1906, with the exception of the Cephalopoda, which are being worked out by Dr. W. E. Hoyle.

The collection, though small, taking into account the area over which dredgings were taken, contains a fair number of interesting species. Though there is nothing new, there are several species represented which one would not expect to find in such high latitudes, and their discovery adds somewhat to our, as yet, slight knowledge of the fauna of the deeper seas and its distribution.

Seventy-five species were identified, divided as follows:—

Amphineura . .	1
Pelecypoda . .	34
Scaphopoda . .	2
Gastropoda . .	37
Nudibranchia . .	1
	75

Of these seventy-five species, sixty-two have been recorded from the British Area, and of the remaining thirteen three are Pelecypods.

Pecten bruéi, Payraudeau.—Mostly known as a Mediterranean species, but has been confounded with *P. sulcata* (Müll.), which is a northern species. They meet in the Bay of Biscay, as both are represented in this collection.

Lima marioni, Fischer.—With reference to this species, Mr. E. A. Smith tells me it is the same as *L. lata*, found by the *Challenger* Expedition and described by him as new in his work dealing with the Lamellibranchs brought home by that expedition. Though an addition

to the fauna of the actual Bay of Biscay, it had been previously found and recorded from off the coast of Portugal by the *Travailleur*.

Lima excavata (Fabricius).—Fragments and odd valves of this northern species have been found south of the Bay of Biscay, by the *Porcupine* off Cape St. Vincent, and by the *Talisman* off the west coast of the Soudan. The single specimen found during the *Huxley* cruise, though smaller than the northern specimens I have seen, contained the animal, and thus proves its extended habitat, which was suggested by the discovery of the above-mentioned fragments.

The two species of Scaphopoda are both recorded as British.

Of the non-British Gastropods, two cannot be identified on account of their condition, but the remaining eight species are of interest.

Emarginula multistriata, Jeffreys. — A Mediterranean species recorded from off the coast of Portugal.

Calliostoma obesulum (P. Fischer) and *C. cleopatra* (P. Fischer) have only been recorded from off the Atlantic coasts of Northern Africa, and the fact of their having been found living, the former in large numbers, so far north, is a valuable indication of the possible very wide distribution of deep-water species.

Natica operculata, Jeffreys.—Jeffreys records the species as having been found by the *Porcupine* off the Spanish coast.

Ranella gigantea (Lamarck).—The most northerly habitat of this species so far recorded.

Scala richardi (Dautzenberg and de Boury).—This species has not been found living, the type being described from a dead shell dredged off the Azores. The remarks applied to the two species of *Calliostoma* apply to this species as well.

Pseudomurex richardi (P. Fischer).—Previously recorded from the Bay of Biscay.

Cavolina trispinosa (Lesueur).—Has an almost world-wide distribution, but is probably killed by coming into cold areas.

I tender my sincere thanks to the following gentlemen for their kind assistance in many ways: Mons. Ph. Dautzenberg, Sir Charles Eliot, K.C.M.G., Mr. E. R. Sykes, B.A., Mr. E. A. Smith, I.S.O., and Mr. H. B. Preston, F.Z.S. Finally I feel very much indebted to Dr. E. J. Allen for allowing me the opportunity of examining a collection of material of very considerable interest in many ways.

MOLLUSCA.

AMPHINEURA.

APLACOPHORA.

NEOMENIIDÆ.

RHOPALOMENIA, Simroth.

Rhopalomenia aglaopheniæ, Kovalevsky and Marion.

Rhopalomenia aglaopheniæ.—Kovalevsky and Marion, 1887. Ann. Mus. Hist. Nat., Marseille, iii.
„ „ Garstang, 1896. Proc. Malac. Soc., Lond. Vol. ii, No. 3, p. 124, pl. x, fig. 3.

Distribution. Plymouth (Garstang) [Banyuls, Marseille].

Station I, 75 fathoms. One coiled round stem of *Aglaophenia myriophyllum.*
„ XIII, 412 „ One coiled but free.

PELECYPODA.

PROTOBRANCHIA.

NUCULIDÆ.

NUCULA, Lamarck.

(1) **Nucula sulcata**, Bronn.

Nucula sulcata, Bronn, 1831. Italiens Tertiärgebild, p. 109.
„ *polii*, Philippi, 1836. Enum. Moll. Sicil., p. 63, pl. v, fig. 10.

Generally distributed in the North Atlantic and throughout the Mediterranean, and as far south as the coast of Guinea. Found in both shallow and deep water.

Station IX. 240 fathoms. One fragment of a broken valve.

(2) **Nucula nitida**, G. B. Sowerby.

Nucula nitida. G. B. Sowerby, 1833. Conch. Ill. (Nucula), p. 5, fig. 20.

Generally distributed in the North Atlantic from Scandinavia to Gibraltar and throughout the Mediterranean.

Station XII. 246 fathoms. One odd valve.

FILIBRANCHIA.

ANOMIACEA.

ANOMIIDÆ.

ANOMIA, Linné.

Anomia ephippium, Linné.

Anomia ephippium, Linné, 1758. Syst. Nat., édit. x, p. 701.

This well-known species has many synonyms and is very variable. All the specimens under consideration are or have been attached to the spines of Echini.

This is a very widely distributed species, and is found on both sides of the Atlantic, "Iceland to Egypt and Madeira, Labrador to Long Island Sound" (Jeffreys). Found by the *Challenger* off Pernambuco, the Nightingale Islands, and Tristan d'Acunha.

Station	IV.	109 fathoms.	One living, young.
,,	IX.	240 fathoms.	Many living, all young.
,,	XI.	146 fathoms.	Two living, both young.
,,	XII.	246 fathoms.	Five living, all young.

ARCACEA.

ARCIDÆ.

LIMOPSIS, Sassi.

(1) **Limopsis aurita** (Brocchi).

Arca aurita, Brocchi, 1815. Conch. Foss. Subapp., ii, p. 485, pl. xi, fig. 9.

Pectunculus auritus, Philippi, 1836. Enum. Moll. Sicil., i, p. 63.

Limopsis aurita, Jeffreys, 1863–69. Brit. Conch., ii, p. 161, pl. iv, fig. 3; v, p. 174, pl. xxx, fig. 1.

A very widely distributed species. Seas of Europe from Norway to the Mediterranean. It has also been recorded from the Azores, New Jersey, Virginia, Cape Hatteras, Georgia, Florida, West Indies. Jeffreys (*Porcupine*, etc.) records it from Japan.

Station	IX.	240 fathoms.	One living, four odd valves.
,,	XII.	246 fathoms.	One living, three odd valves.

(2) **Limopsis minuta** (Philippi).

Pectunculus minutus, Philippi, 1836. Enum. Moll. Sicil., i, p. 63, pl. v, fig. 3.

Limopsis Borealis, Woodward, 1865. In Jeff. Brit. Conch., v, p. 174, pl. 100, fig. 3.

Limopsis minuta, Jeffreys, 1879. Proc. Zool. Soc., p. 585, pl. xlvi, fig. 9.

This species has a very wide distribution. It has been recorded from the North Atlantic, on the east side, from the Loffodens to the Canary Islands, on the west from New Jersey to the Gulf of Mexico, also from Barbados and in the Mediterranean.

Station XII. 246 fathoms. Five odd valves.

Glycymeris, da Costa.

Glycymeris glycymeris (Linné).

Arca glycymeris, Linné, 1758. Syst. Nat., édit. x, p. 695.

Glycymeris orbiculata, da Costa, 1778, p. 168, pl. xi, fig. 2.

Pectunculus pilosus, etc., Turton, 1822. Conch. Insul. Brit., pp. 172–4, pl. xii, figs. 2–6 (non Linné).

Generally distributed in the European seas, though rare in the Mediterranean; also found on the Senegal coast, Madeira, and the Canary Islands. Jeffreys records it from the north of Japan.

Station I. 75 fathoms. Two living, one very young.
,, V. 109 fathoms. One odd valve.

Arca, Linné.

(1) **Arca nodulosa**, Müller.

Arca nodulosa, Müller, 1766. Zool. Daniæ Prodr., p. 247.

,, *scabra*, Poli, 1795. Test. utr. Siciliæ, ii, pl. xxv, fig. 22.

Barbatia scabra, Brusina, 1886. Contr. Fauna Dalmat., p. 101.

Arca (Barbatia) scabra, Dautzenberg et H. Fischer, 1897. In Mém. Soc. Zool. France, x, p. 199.

Appears to be a widely distributed species in the Atlantic Ocean, north of the equator, and is recorded from the Hebrides, Faroe Islands, British coasts, Bay of Biscay, Portugal coast, Senegal, Canary Islands, Gulf of Mexico, and the Florida coast; it is also found throughout the Mediterranean Sea.

Station VII. 444 fathoms. Twelve of various ages and all living.
,, XIII. 412 fathoms. Twenty-five of various ages, all living with the exception of a couple of odd valves.

(2) **Arca obliqua**, Philippi.

Arca obliqua, Philippi, 1844. Enum. Moll. Sicil., vol. ii, p. 43, pl. 15, fig. 2.

,, ,, Jeffreys, 1863. Brit. Conch., vol. ii, p. 175; vol. v, p. 175, pl. xxx, fig. 4.

Distribution, Bergen and Shetland to the Ægean, Azores (Jeffreys). Not recorded as being found during either the *Caudan* or *Travailleur* and *Talisman* expeditions.

Station V. 109 fathoms. One, living.

MYTILACEA.

MYTILIDÆ.

VOLSELLA, Scopoli.

Volsella phaseolina (Philippi).

Modiola phaseolina, Philippi, 1844. Enum. Moll. Sicil., ii, p. 51, pl. xv, fig. 14.

Widely distributed from Iceland and Finmark to the Straits of Gibraltar and throughout the Mediterranean. Not recorded as having been found during the *Travailleur* and *Talisman* expeditions, nor that of the *Caudan*.

Station II. 75 fathoms. Two, living.

PSEUDOLAMELLIBRANCHIA.

PECTENIDÆ.

PECTEN, Müller.

Pecten bruei, Payraudeau.

Pecten bruei, Payraudeau, 1826. Moll. Corse, p. 78, pl. ii, figs. 10–14.

„ *leptogaster*. Brusina, 1866. Contr. Fauna Dalmat., p. 45.

This species appears to me to be easily separable from *P. sulcata*, being much more regularly and definitely costulated, and our solitary specimen is quite typical of the species with the exception of its being without colour. Its geographical range seems limited to the Mediterranean and Atlantic coasts of Europe from the Bay of Biscay to the south of Cape Verde. Our specimen was dredged further to the north than any previously recorded.

Station IX. 240 fathoms. One living.

CHLAMYS, Bolten.

Chlamys sulcatus (Müller).

Pecten sulcatus, Müller, 1776. Zool. Daniæ Prodr., p. 248.

Ostrea arata, Gmelin, 1789. Systema Naturæ, édit. xiii, p. 3326.

Pecten aratus, G. O. Sars, 1878. Moll. Reg. Arct. Norveg., p. 17, pl. 11, fig. 3.

Locard's reference, in his *Travailleur* and *Talisman* mollusca,

to the synonymy of this species in Forbes and Hanley's "History of British Mollusca," 1855, vol. ii, p. 281, is a mistake, for this refers to *P. striatus*, Müller, and it is not surprising he found the synonymy very complex and doubtful. I have not been able to find any mention of *P. sulcatus* in Forbes and Hanley's work except J. Sowerby's fossil variety of *P. opercularis*.

The only identified specimens of this species I have been able to inspect are in the National Collection, and with the exception that they are richly coloured and somewhat larger and more solid than the specimens under consideration, I can see no difference.

The range of this species is considerable, and if we omit the Mediterranean locality given by Jeffreys as doubtful, it has been recorded in the Atlantic from Norway and the Faroe Islands to the seas west of the coast of the Soudan.

Station XIII. 412 fathoms. One living, young; three dead valves of various ages.

ÆQUIPECTEN, Fischer.

Æquipecten opercularis (Linné).

Ostrea opercularis, Linné, 1758. Syst. Nat., édit. x, p. 698.

Pecten opercularis, Montagu, 1803. Test. Brit., p. 145.

Chlamys (*Æquipecten*) *opercularis*, P. Fischer, 1886. Man. Conch., p. 944.

Generally distributed in the European seas and Asiatic and African coasts of the Mediterranean and off the Azores. From 5 fathoms to 600 or more. Locard remarks that the shells dredged by the *Caudan* were much smaller than usual, and the same can be stated of the living shells under consideration, the largest of which measures only 21 mm. by 20 mm. in breadth. The dead shells and fragments show that the species attains a much larger growth in the same locality.

Station I. 75 fathoms. One living (small). Three odd valves of various sizes.

Station II. 75 fathoms. One living, one dead, and an odd valve.

„ IV. 109 fathoms. Four fragments.

„ V. 109 fathoms. Many small living and dead and broken fragments of larger shells.

Station XI. 146 fathoms. One living (small), and two odd valves.

PALLIOLUM, Monterosato.

(1) **Palliolum similis** (Laskey).

Pecten similis, Laskey, 1811. In Mem. Werner Soc., i, p. 387, pl. viii, fig. 8.

Pecten tumidus, Turton, 1822. Conch. Insul. Brit., p. 212, pl. xvii, fig. 3.

Found generally in the seas of Europe and on the African coast of the Mediterranean.

Station V. 109 fathoms. Two living.

(2) **Palliolum vitreus** (Chemnitz).

Pallium vitreum, Chemnitz, 1782. Conch. Cab., vii, p. 335, pl. lxvii, fig. 637*a*.

Chlamys vitrea, Dautzenberg, 1889. Contr. Faune Mala. Açores, p. 76.

A very widely distributed species in the North Atlantic, found on both the American and European coasts.

Station VII. $\dot{\overline{444}}$ fathoms. Seventeen living, of various sizes, and one odd valve.

Station XIII. 411 fathoms. Two living.

LIMIDÆ.

Lima, Brugière.

(1) **Lima excavata** (Fabricius).

Ostrea excavata, Fabricius, 1780. In Schroter's Naturg., ii, p. 117.

Excavata fabricii, Chemnitz, 1784. Conch. Cab., vii, p. 355, pl. lxviii, fig. 654.

Lima excavata, Loven, 1846. Index. Moll. Scand., p. 32.

Radula (*Acesta*) *excavata*, Dautzenberg et H. Fischer, 1897. In Mém. Soc. Zool., France, x, p. 186.

This species must be much more generally distributed than was at one time supposed, for in 1883 the *Talisman* dredged it off the west coast of the Soudan. The *Lightning* and *Porcupine* only found fragments, though Jeffreys remarks in one case (*Lightning*, 1868, north of Hebrides, St. 5) the pieces were quite fresh and united by the cartilage.* *Lima excavata* has usually been considered to be confined to almost Arctic seas.

Station VII. $\dot{\overline{444}}$ fathoms. One living.

(2) **Lima marioni**, P. Fischer.

Lima marioni, P. Fischer, 1882. In Journ. Conch., xxx, p. 52.

„ *lata*, Smith, 1885. Voy. *Challenger*, xiii, p. 257, pl. xxiv, fig. 3.

* Those found by the *Porcupine* (1870) off St. Vincent were semi-fossil.

Radula lata, Dautzenberg et H. Fischer, 1897. In Mém. Soc. Zool., France, x, p. 186.

Apparently a very widely distributed deep-water species.

Challenger, N.E. of Brazil, Philippine Islands.

Hirondelle and *Princess Alice*. Off the Azores.

Travailleur. West of Portugal.

Talisman. West coasts of Morocco and the Soudan.

Station VII. 444 fathoms. Eight living, of various sizes.

" XIII. 412 fathoms. Seven living, of various sizes, one curiously malformed.

(3) **Lima subauriculata** (Mont.).

Pecten subauriculatus, Montagu, 1808. Test. Brit. Suppl., p. 63, pl. xxix, fig. 2.

Lima subauriculata, Turton, 1822. Conch. Insul. Brit., p. 218.

" *sulcata*, Brown, 1827. Ill. Conch. Gt. Britain, pl. xxxi, fig. 4–5.

" *nivea*, Philippi, 1836. Enum. Moll. Sicily, vol. i, p. 78.

Found on both sides of the Atlantic, in the Mediterranean, and off the Canary Isles.

Station V. 109 fathoms. One valve.

EULAMELLIBRANCHIA.

SUBMYTILACEA.

ASTARTIDÆ.

ASTARTE, J. Sowerby.

Astarte sulcata (da Costa).

Pectunculus sulcatus, da Costa, 1778. Brit. Conch., p. 192.

Venus danmonana, Montagu, 1808. Test. Brit. Suppl., p. 45, pl. xxix, fig. 4.

Astarte sulcata, Fleming, 1828. Hist. of Brit. Anim., p. 439.

" " Forbes and Hanley, 1853, Hist. Brit. Moll., i, p. 452, pl. xxx, fig. 6 (as *A. danmoniensis*).

A difficult species, very variable, and provided with many synonyms. Generally distributed in European seas, Siberia, East Greenland, North-east America, Gulf of Mexico, Canaries.

Station I. 75 fathoms. One odd valve.

" II. 75 fathoms. One living.

" IX. 240 fathoms. One living, and several odd valves.

" XII. 246 fathoms. One living, and several odd valves (small).

TELLINACEA.

SCROBICULARIDÆ.

SYNDOSMYA, Récluz.

Syndosmya prismatica (Mont.).

Ligula prismatica, Montagu, 1808. Test. Brit. Suppl., p. 23, pl. xxvi, fig. 3.

Scrobicularia prismatica, Jeffreys, 1863–69. Brit. Conch., vol. ii, p. 435; vol. v, p. 189, pl. xlv, fig. 1.

Generally distributed throughout the seas of Europe.

Station II. 75 fathoms. Three odd valves.
" XI. 146 fathoms. Three odd valves.

MACTRIDÆ.

SPISULA, Gray.

Spisula elliptica (Brown).

Mactra elliptica, Brown, 1827. Ill. Conch. Gt. Brit., pl. xv, fig. 6.
" *gracilis*, Locard, 1890. In Bull. Soc. Maloc. France, vii, p. 4, pl. i, fig. 1.

With Mr. E. A. Smith's help I carefully compared these specimens with those dredged by the *Porcupine* expedition, but still felt very doubtful as to their true specific position. I submitted them to Mons. Dautzenberg, whose works on the North Atlantic mollusca are well known, and he confirms my opinion, and says, "it is the true *M. elliptica* of Brown, but not of the greater number of authors, and the *M. gracilis* of Locard is a synonym."

This species is probably widely distributed in the North Atlantic. The Gulf of Cadiz is the locality given by Mons. Locard for the single valve found by the *Talisman* expedition.

Station I. 75 fathoms. Eight odd valves.
" II. 75 fathoms. One living, and ten odd valves.
" V. 109 fathoms. Two living.
" XI. 146 fathoms. Three living, and two odd valves.

VENERACEA.

VENERIDÆ.

LUCINOPSIS, Forbes and Hanley.

Lucinopsis undata (Pennant).

Venus undata, Pennant, 1777. British Zoology, ed. 4, vol. iv, p. 95, pl. lv, fig. 51.

Lucinopsis undata, Forbes and Hanley, 1853. Hist. Brit. Moll., vol. i, p. 435, pl. xxviii, figs. 1 and 2, pl. M, figs. 1 and 2.

This species is widely distributed in the seas of Europe, from Norway and the Loffoden Isles to Spain and Portugal, and in the Mediterranean as far east as the Adriatic.

Station V. 109 fathoms. One odd valve.

VENUS, Linné.

(1) **Venus (Ventricola) casina** (Linné).

Venus casina, Linné, 1758. Syst. Nat., édit. x, p. 685.

This species is known under a dozen or more synonyms, which appear to me to be unnecessary to repeat, as the shell is well known, and they can be found in many standard works.

Generally distributed in European seas, and also off the Canary Islands and Madeira.

Station I. 75 fathoms. One living and one odd valve.
" IV. 109 fathoms. Five living and many odd valves.
" V. Two living; young shells.

(2) **Venus (Timoclea) ovata** (Pennant).

Venus ovata, Pennant, 1767. Brit. Zool., iv, p. 97, pl. lvi, fig. 56.

Cytherea radiata, Stossich, 1866. Enum. Moll. Trieste, p. 31.

This species has many other synonyms.

Generally distributed in European seas and the Mediterranean coast of Africa.

Station I. 75 fathoms. Several odd valves.
" II. 75 fathoms. One odd valve.
" V. 109 fathoms. One living and several odd valves.
" XI. 146 fathoms. Four living and several odd valves.
" XII. 246 fathoms. Two odd valves.

GOULDIA, C. B. Adams.

Gouldia minima (Montagu).

Venus minima, Montagu, 1803. Test. Brit., p. 121, pl. iii, fig. 3.

Cyprina minima, Turton, 1822. Conch. Insul. Brit., p. 137.

Cytherea minima, Brown, 1827. Ill. Conch., Gt. Britain, pl. xix, fig. 3.

Circe minima, Forbes and Hanley, 1853. Hist. Brit. Moll., 1, p. 446, pl. xxvi, figs. 4, 5, 6, 8.

Circe (*Gouldia*) *minima*, P. Fischer, 1887. Man. Conch., p. 1081.

This species has a very extended synonymy. Locard gives twenty-three, but in a paper of this sort such an extension seems needless, the shell being common enough and well-known. Its distribution is general in the North Atlantic, from Great Britain to the Azores, and throughout the Mediterranean.

Station V. 109 fathoms. Two odd valves.

CARDIACEA.

Cardium, Linné.

(1) **Cardium minimum**, Philippi.

Cardium minimum, Philippi, 1836. Enum. Moll. Sicil., i, p. 51.
„ „ „ 1844. Loc. cit., ii, p. 38, pl. xiv, fig. 18.
„ *saldiense*, Reeve, 1845. Conch. Icon., pl. xxii, fig. 132.
„ *loveni*, Thompson, 1845. In Ann. Mag. Nat. Hist., xv, p. 317, pl. xix, fig. 7.
„ *suecicum*, Lovén, 1846. Index. Moll. Scand., p. 189.

Very widely distributed in European seas, from the Loffoden Isles and Norway as far east as Siberia in Asia, British, French, Spanish, and Portuguese coasts, and, though rarer, throughout the Mediterranean. In shallow and very deep water.

Station IX. 240 fathoms. One specimen, perfect though dead.

(2) **Cardium (Lævicardium) norvegicum** (Spengler).

Cardium lævigatum, da Costa, 1778. Brit. Conch., p. 178, pl. xiii, fig. 6.
„ *norvegicum*, Spengler, 1790. Skrift. Natur. Selsk., i, p. 42.
„ *crassum*, Gmelin., 1790. Syst. Nat., éd. xiii, p. 3354.
„ *serratum*, de Lamarck, 1819. Anim. sans Vert., vi, i, p. 11.
„ *vitellinum*, Reeve, 1844. Conch. Icon., pl. vii, fig. 77.

Lævicardium norvegicum, H. and A. Adams, 1858. Gen. Rec. Moll., ii, p. 457, pl. cxii, fig. 2.

Cardium (*Lævicardium*) *norvegicum*, Issel, 1878. Croc. del "Violante," p. 37.

Generally distributed in the European seas, off Madeira, the Canary Isles, and coast of Senegal.

Station IV. 109 fathoms. One broken valve.

MYACEA.

GARIDÆ.

Gari, Schumacher.

Gari costulata (Turton).

Psammobia costulata, Turton, 1822. Conch. Insul. Brit., p. 87, pl. vi, fig. 8.
„ *discors*, Philippi, 1836. Enum. Moll. Siciliæ, i, p. 23 pl. iii, fig. 8.

Distributed in the Atlantic Ocean, from Norway to Madeira and the Canary Islands, and throughout the Mediterranean.

Station V. 109 fathoms. One specimen, dead, but the valves attached

SAXICAVIDÆ.

SAXICAVA, Fleuriau Bellevue.

Saxicava arctica (Linné).

Mya arctica, Linné, 1766. Systema Naturæ, édit. xii, p. 1113.

The synonymy of this genus or species is very much involved, the number of species still being a very open question. Mr. E. A. Smith's opinion is that *rugosa* is the only species, the other so-called ones being varieties. The shells under consideration are undoubtedly the *rugosa* var. *arctica* figured by Jeffreys in his "British Conchology," v, pl. li, fig. 4. Generally distributed in the North Atlantic, from Greenland and Norway to Cadiz Bay, and in the Mediterranean.

Station I. 75 fathoms. Six living.
„ II. 75 fathoms. Two living.

ANATINACEA.

PANDORIDÆ.

PANDORA, Brugière.

Pandora inæquivalvis (Linné).

Tellina inæquivalvis, Linné, 1766. Systema Naturæ, édit. xii, p. 1118.

Pandora rostrata, Forbes and Hanley, 1853. Hist. Brit. Moll., vol. i, p. 207, pl. viii, figs. 1–4.

One valve only in poor condition, and this circumstance makes an examination of Mons. Locard's remarks, when dealing with *P. pinnoides* (Moll. Test. Trav. et Tal.) of doubtful utility, though he appears to have had only one specimen to base his conclusions on.

Station V. 109 fathoms. One left valve.

LYONSIIDÆ.

LYONSIA, Turton.

Lyonsia norvegica (Chemnitz).

Mya norvegica, Chemnitz, 1788. Conch. Cab., vol. x, p. 345, pl. 170, f. 1647.

Lyonsia striata, Turton, 1822. Conch. Insul. Brit., p. 35, pl. 3, figs. 6, 7.

Hyatella striata, Brown, 1827. Ill. Conch. Gt. Brit., pl. xvi, figs. 26, 27.

Generally distributed throughout the European seas and Mediterranean.

Locard splits this species into two, *norvegica* (Chem.) and *striata* (Mont.). Not having sufficient material at hand, I am content to let the generally accepted name stand for the present.

Station I. 75 fathoms. One living.

ANATINIDÆ.

THRACIA, Leach in Blainville.

Thracia papyracea (Poli).

Tellina papyracea, Poli, 1795. Test. Utr. Sic., vol. i, p. 43, pl. xv, figs. 14, 18.

Thracia phaseolina, Forbes and Hanley, 1853. Hist. Brit. Conch., vol. i, p. 221, pl. xviii, figs. 5, 6.

Ranges from Iceland and Loffoden Isles to throughout the Mediterranean, Madeira, the Canary Isles. Locard does not mention this species at all as having been found by the *Talisman* and *Travailleur* expeditions, or the *Caudan* expedition. Jeffreys reports it from the *Porcupine* expeditions of 1869–70.

Station V. 109 fathoms. One valve and three fragments.

SEPTIBRANCHIA.

CUSPIDARIIDÆ.

CUSPIDARIA, Nardo.

(1) **Cuspidaria abbreviata** (Forbes).

Neæra abbreviata, Forbes, 1843. In Proc. Zool. Soc., Lond., p. 75.

Neæra vitrea, Lovén, 1846. Ind. Moll. Scand., p. 48.

Cuspidaria (*Tropidomya*) *abbreviata*, Dautzenberg, 1881. Mem. Soc. Zool., Fr., iv., p. 612.

Atlantic and Mediterranean: from Norway and the West of Ireland to Algiers and the Ægean Sea.

Station XII. 246 fathoms. Two odd valves.

(2) **Cuspidaria cuspidata** (Olivi).

Tellina cuspidata, Olivi, 1792. Zool. Adriat., p. 101, pl. iv, fig. 3.

Corbula cuspidata, Philippi, 1836. Enum. Moll. Sicil., i, p. 17, pl. i, fig. 19.

Appears to have the same geographical distribution as the last species. Locard doubts if the Mediterranean form is the same as the Atlantic, and proposes Brown's name *brevirostris* for the latter. I have carefully compared, with Mr. E. A. Smith's kind assistance, our specimens with those from the *Porcupine* expedition, in the British Museum.

Station XI. 146 fathoms. One odd valve.
" XII. 246 fathoms. One odd valve.

(3) **Cuspidaria curta** (Jeffreys).

Neæra curta, Jeffreys, 1876. In Ann. and Mag. Nat. Hist., 4th Ser. xviii, p. 495.

„ „ „ 1881. Proc. Zool. Soc., Lond., p. 943, pl. lxxi, fig. 10.

Cuspidaria curta, Dautzenberg, 1883. Contr. Faune Malac., Açores, p. 88.

Known only from the Atlantic, in which it is widely distributed on both sides, from the Behring Straits to the Bermudas and from the Bay of Biscay to Morocco.

Station XII. 246 fathoms. Two odd valves.

SCAPHOPODA.

DENTALIIDÆ.

DENTALIUM, Linné.

(1) **Dentalium entalis**, Linné.

Dentalium entalis, Linné, 1758. Syst. Nat., éd. x, p. 785.

„ „ Forbes and Hanley, 1853. Hist. Brit. Moll., vol. ii., p. 449, pl. lvii., fig. 11.

According to Jeffreys this species is much more common in the north than in the south of England. He remarks also that he has not been able to identify this species as Mediterranean or Adriatic, though the name occurs in nearly all the accounts of the shells of those seas. Locard, on the contrary, gives various localities in those seas for this species, on the coasts of Spain, France, Italy, Corsica, Malta, African coast, Gulf of Gabes, and also mentions Vigo, the Azores, and Cape Bonne Esperance as Atlantic localities. It has also been recorded from Iceland, Loffoden Isles, Northern Russia, Maine, and Vancouver Island in North America.

Station I. 75 fathoms. Several; living and dead.
„ V. 109 fathoms. Three living.
„ IX. 240 fathoms. Two, one living, one large fragment much corroded.
„ XI. 146 fathoms. Five, all dead, some fragmentary.

(2) **Dentalium panormitanum (panormum)** (Chenu).

Dentalium panormum, Chenu, 1842–47. Ill. Conch., pl. vi, fig. 13.

Dentalium lessoni, Sowerby, 1842–83. Thesaur. Conch., pl. xv, fig. 18.

A rather difficult species, and I can find only one specimen in the British Museum (Nat. Hist.), and this appears to be similar to the solitary specimen under consideration, which is in rather a bad state. Jeffreys (Moll. of *Lightning-Porcupine* Expds., 1868–70, part v, P. Z. S., 1882, p. 657) decides in favour of its validity. It is a rare shell, which has been recorded only from the Bay of Biscay, Portuguese and Spanish coasts, and in the Adriatic. The *Talisman* dredged it off Senegal and in the tropical seas, in 1883, from four stations.

Station IX. 240 fathoms. One dead, corroded shell.

GASTROPODA.

PROSOBRANCHIA.

ASPIDOBRANCHIA.

RHIPIDOGLOSSA.

FISSURELLIDÆ.

PUNCTURELLA, R. T. Lowe.

Puncturella noachina (Linné).

Patella noachina, Linné, 1767. Mantissa plantarum, p. 551.

„ *fissura*, Müller, 1788–1806. Zool. Daniæ, pl. xxiv, figs. 5, 6.

Syphostriata noachina, T. Brown, 1827. Ill. Conch. Gt. Brit., etc., pl. xxxvi, figs. 14–16.

Cemoria noachina, Gould, 1841. Invert. Mass., p. 156, fig. 18.

Rimula Flemingii. Macgillivray, 1843. Hist. Moll. Anim. Aberdeen, etc., pp. 65 and 178.

This species is very widely distributed in the seas of the sub-polar and temperate regions of the world.

Station XII. 246 fathoms. One dead.

EMARGINULA, Lamarck.

(1) **Emarginula fissura** (Linné).

Patella fissura, Linné, 1758. Syst. Nat. édit. x, p. 784.

Emarginula reticulata, Forbes and Hanley, 1853. Hist. Brit. Moll., ii, p. 477; figured as *Mülleri*, iv, pl. 63, fig. 1.

Generally distributed in the European seas and off the Canary Isles.

Station I. 75 fathoms. One dead

(2) **Emarginula multistriata**, Jeffreys.

Emarginula multistriata, Jeffreys, 1882. In Ann. Mag. Nat. Hist., p. 30.

" " " " Proc. Zool. Soc., p. 680, pl. l, fig. 12.

Recorded from the Atlantic, off the coast of Portugal, and from the Mediterranean.

Station VII. 444 fathoms. One dead shell.

TROCHIDÆ.

CALLIOSTOMA, Swainson.

(1) **Calliostoma obesulum** (P. Fischer).

Zizyphinus obesulus, P. Fischer, 1883, in Collect.

Gibbula obesula, Locard, 1898. Exp. Sci. Trav. et Talis., ii, p. 47, pl. iii, figs. 1–4.

This is another species that seems to have been previously recorded only from the coast of Morocco and the Soudan coast of the North Atlantic. Locard's figures above-mentioned are not particularly good, and I am indebted to Mons. Dautzenberg for its correct identification, the species not being represented in our National Collection.

Station VII. 444 fathoms. Twenty-four living, one fragment.
" XIII. 412 fathoms. One living, two dead.

(2) **Calliostoma cleopatra** (P. Fischer).

Trochus cleopatra, P. Fischer, 1883, in Collect.

Zizyphinus cleopatra, Locard, 1898. Exp. Sci. Trav. et du Tal., vol. ii, pl. ii, figs. 20–23.

Only recorded by Locard from one station (*Talisman*, 1883, Station 83) off the Sahara coast, and the fact of this scarçe shell turning up, living, in the north of the Bay of Biscay is very interesting.

Station VII. 444 fathoms. One living.

(3) **Calliostoma miliaris** (Brocchi).

Trochus miliaris, Brocchi, 1814. Conch. Foss. Subappen., p. 253, pl. iv, fig. 1.

Trochus millegranus, Philippi, 1836. Enum. Moll. Sicil., I, p. 183, pl. x, fig. 25.

Zizyphinus miliaris, Locard, 1886. Prodro. Conch., Franc., p. 309.

Calliostoma miliaris, Pilsbry, 1889. Man. Conch., part xliv*a*, p. 387, pl. xviii, figs. 10, 11.

Generally distributed in the North Atlantic and throughout the Mediterranean in shallow and deep water.

Station I. 75 fathoms. One young, dead.

(4) **Calliostoma granulatum** (Born.).

Trochus granulatus, Born, 1778. Ind. Rerum Nat. Mus. Vindobon, p. 343.

Trochus papillosus, da Costa, 1778. Brit. Conch., p. 38, pl. iii, figs. 5 and 6.

Trochus fragilis, Pultney, 1799. Cat. Dorset Shells, p. 48, pl. xvi, fig. 6.

Trochus tenuis, Montagu, 1803. Test. Brit., i, p. 275, pl. x, fig. 3.

Fairly distributed in European seas, Britain, France, Spain, and Portugal. In the Mediterranean and Adriatic, Morocco, Madeira, Canaries, etc.

Station V. 109 fathoms. Five living, including one *var.* lactea (Jeff.) and one young shell.

Station VI. 87 fathoms. One living.

PECTINIBRANCHIA.

TÆNIOGLOSSA PLATYPODA.

CAPULIDÆ.

CAPULUS, de Montfort.

Capulus hungaricus (Linné).

Patella ungarica, Linné, 1758. Syst. Nat. édit. x, p. 782.

Pileopsis hungaricus, Forbes and Hanley, 1853. Hist. Brit. Moll., vol. ii, p. 459, pl. lx, figs. 1 and 2 (as *C. hungaricus*).

A widely distributed species, ranging from Iceland, Norway, and the Eastern coasts of Europe to the Azores, and throughout the Mediterranean to the south-east coasts of the United States. It was not found by either the *Caudan* or *Travailleur* and *Talisman* expeditions.

Station IV. 109 fathoms. One living on Venus verrucosa.

NATICIDÆ.

NATICA, Scopoli.

(1) **Natica (Lunatia) sordida** (Philippi).

Natica sordida, Philippi, 1844. Enum. Moll. Siciliæ, ii, p. 139, pl. xxiv, fig. 15.

British seas, and very generally distributed in the European seas, including the Mediterranean, and off Madeira.

The synonymy of this species is not very clear. Locard considers it to be the *N. fusca* of Blainville, 1821. (Dict. des Sciences Nat.)

The specimens under consideration are all young, but compare very well with those in the British Museum (Nat. Hist.) from the *Lightning* and *Porcupine* expeditions.

Station IX. 240 fathoms. Three dead.
,, XII. 246 fathoms. Three dead.

(2) **Natica (Lunatia) catena** (da Costa).

Cochlea catena, da Costa, 1778. Brit. Conch., p. 83, pl. v, fig. 7.

Natica monilifera, Lamarck, 1822. Anim. s. Vert., vi, ii, p. 199.

Natica catenata, Locard, 1886. Prodr., p. 274. 1892. Conch. Franc., p. 182, fig. 157.

Generally distributed in the European seas.

Jeffreys does not appear to have recorded this species in his mollusca of the *Lightning* and *Porcupine* expeditions, nor is it mentioned by Locard as having been found during the *Travailleur* and *Talisman* expeditions, but he records it as commonly found in the Gulf of Gascogny cruise of the *Caudan*.

Station II. 75 fathoms. One dead.

(3) **Natica (Lunatia) alderi** (Forbes).

Natica alderi, Forbes, 1838. Malac. Monensis, p. 31, pl. ii, figs. 6, 7.

„ *nitida*, Forbes and Hanley, 1853. Hist. Brit. Moll., iii, p. 330, pl. C (100), figs. 2–4.

Jeffreys (P.Z.S., Jan. 20th, 1885, p. 30) considered this species to be identical with Linné's *N. glaucina* (Fauna Suecica, ed. 2, p. 533, No. 2197), while Locard ("Travailleur et Talisman") decides that he described under this name several European Naticas. The latter also removes *Natica poliana*, Delle Chiaje, from the synonymy of this species, thus making it more an oceanic species by excluding it from the Mediterranean list, and giving *Natica poliana* specific rank.

British seas and the oceanic coasts of Europe and the Sahara coast of Africa.

Station V. 109 fathoms. Eight dead, of various sizes.
Station XI. 146 fathoms. One dead, small, broken.

(4) **Natica (Lunatia) montagui** (Forbes).

Natica montagui, Forbes, 1838, Malac. Monensis, p. 172, pl. ii, figs. 3, 4.

Lunatia montagui, G. O. Sars, 1878. Moll. Reg. Arch. Norvegiæ, p. 157.

Natica montacuti, Jeffreys, 1885. In P.Z.S., Lond., p. 31.

British and European seas, including the Mediterranean.

Station V. 109 fathoms. Three dead.
,, XI. 146 fathoms. Three, one living, two dead.
,, XII. 246 fathoms. One dead, which appears to be *var. conica* of Jeffreys.

(5) **Natica (Lunatia) operculata** (Jeffreys).

Natica operculata, Jeffreys, 1885. Proc. Zool. Soc., p. 34, pl. iv, fig. 7.

Distributed in the North Atlantic. Jeffreys' localities are from the neighbourhood of Cape St. Vincent to south-west of Cadiz, and in the Mediterranean, Adventure Bank. He also gives North Japan (St. John) as a habitat.

I am indebted to Mons. Dautzenberg for the identification of the one small specimen.

Station I. 75 fathoms. One, small, dead.

LAMELLARIIDÆ.

Lamellaria, Montagu.

Lamellaria perspicua (Linné).

Helix perspicua, Linné, 1758. Syst. Nat., édit. x, p. 775.

According to Jeffreys, the distribution of this species is Norway, Faröe Islands, Great Britain, Ireland, Brest (Daniel), Atlantic coasts of France and Spain (Hildago), throughout the Mediterranean and Adriatic, Canaries (McAndrew), Labrador, Canada, and the United States.

This species is not recorded by either the *Caudan* or *Travailleur* and *Talisman* expeditions.

Mons. Dautzenberg records it from San Miguel and Pico in the Azores, remarking that all the examples were young, the shell hyaline white, marked with three opaque bands.

Station VI. 87 fathoms. Five living, two male, three female.

TRITONIIDÆ.

Ranella, Lamarck.

Ranella gigantea (Lamarck).

Murex reticularis, Born, 1780. Test. Mus. Cæsar, Vindobon, pl. xi, fig. 51, non Linné.

Argobuccinum (*Gyrina*) *gigantea*, Dautzenberg, 1892. In Mem. Soc. Zool., France, iv, p. 605.

Locard considers that the shell found in the Atlantic differs from that found in the Mediterranean, and calls them *var. atlantica* and *var. mediterranea*, the sculpture of the latter being stronger than in the former. Not having had the opportunity of examining a large series from both localities, I do not care to offer an opinion, as Locard also remarks that the Atlantic variety was not always confined to this habitat, as he has found it in the Post-pliocene of Italy.

Station IV. 109 fathoms. Four living, two male, two female, the latter being the largest. This appears to be the most northernly record for this species.

SCALIDÆ.

SCALA, Humphrey.

(1) Scala clathrus (Linné).

Turbo clathrus, Linné. Syst. Nat., 1758, éd. x, p. 765 (partly).
Scalaria communis, Lamarck. An. s. Vert. 1822, vi. (2), p. 228.
„ „ Forbes and Hanley, 1853, Hist. Brit. Moll. pl. lxx, figs. 9 and 10.

Dredged by the *Porcupine*, 1869, in Donegal Bay, 1870, off Cape Sagres, and in the Mediterranean at Algeciras Bay and on the Adventure Bank.

Station I. 75 fathoms. One dead shell.

(2) Scala trevelyana (Leach in Johnston).

Scalaria trevelyana (Leach MS.), 1853. In Forbes and Hanley, Hist. Brit. Moll., iii, p. 213, pl. lxx, figs. 7 and 8; pl. FF, figs. 1–3.

Distribution, North Atlantic, from Norway to the Sahara coast.

Station XI. 146 fathoms. One dead shell.

(3) Scala richardi (Dautzenberg et de Boury).

Scalaria richardi, Dautzenberg and de Boury, 1897. Mem. Soc. Zool. de France, x, p. 68, pl. ii, fig. 5.

Dredged by the *Hirondelle*, 1888, off the Azores; and *Princess Alice*, 1895, also off the Azores.

None but dead shells seem to have been found, and the species was described from imperfect specimens.

Station IX. 240 fathoms. One dead shell with the mouth imperfect.

TURRITELLIDÆ.

TURRITELLA, Lamarck.

Turritella communis, Risso.

Turritella communis, Risso, 1826. Hist. Nat. Europe Mérid., iv, p. 106, fig. 37.

This well-known species has an extensive habitat in the seas of Europe, living as far north as the Faroe Islands. It is found throughout the Mediterranean and off the coast of Morocco.

Locard splits this species into two on the strength of distinctions pointed out by de Monterosato, but I do not know how far this distinction has been adopted, nor have I been able to inspect a series of each. Our solitary specimen is both young and damaged, but can be without doubt referred to the *var. gracilis* of Jeffreys.

Station XI. 146 fathoms. One dead, young and broken.

TRICHOTROPIDÆ.

TORELLIA, Jeffreys.

Torellia vestita, Jeffreys.

Recluzia aperta, Jeffreys, 1859. Ann. Mag. Nat. Hist., 3rd ser., iii, p. 114, pl. iii, fig. 22 a–c.

Torellia vestita, Jeffreys, 1867. Brit. Conch., iv, p. 244, pl. iv, fig. 1; v, pl. lxxix, fig. 5.

Little seems to be known as to the distribution of this species. Jeffreys mentions Loffoden Isles southwards on the authority of Lovén and others, Shetland (Barlee) and New England coasts of the United States (Verrill). It is not recorded from either the *Travailleur*, *Talisman*, or *Caudan* expeditions, which makes this an interesting Bay of Biscay record.

Station XIII. 412 fathoms. One living.

STENOGLOSSA.

RHACHIGLOSSA.

BUCCINIDÆ.

BUCCINUM, Linné.

(1) **Buccinum undatum** (Linné).

Buccinum undatum, Forbes and Hanley, 1853. Hist. Brit. Moll., iii, p. 401, pl. cix, figs. 3 and 5.

This species seems to be confined to the North Atlantic, its habitat extending from the North Cape (Sars, Friele), and Iceland (Steenstrup), to the north, Massachusetts (Gould), Cape Hatteras (Dall.), New York State (De Kay, Smith, Prime, Tryon, Man. Conch.), to the west, and Rochelle (D'Orbigny père and Aucapitaine) to the south.

It is not recorded by Locard as having been found in either the *Travailleur*, *Talisman*, or *Caudan* expeditions.

Station I. 75 fathoms. One living.
,, II. 75 fathoms. One dead and one fragment.
,, V. 109 fathoms. One living and two young shells dead.
,, VI. 87 fathoms. One living and one dead.

Remarks.—The shells are much thinner than those usually found in the English Channel and southern part of the North Sea, and might be considered as approaching the variety *striata*, Pennant.

(2) **Buccinum**, Sp.

Two young living specimens of some species; without further material it is not much use attempting to give them a specific position. Mons. Dautzenberg suggests they may be the young of *B. schneideri*, Verkrüzen.

Station V. 109 fathoms. Two living, young.

LIOMESUS, Stimpson.

Liomesus dalei (J. Sowerby).

Buccinum dalei, J. Sowerby, 1825. Min. Conch., p. 139, pl. 486, figs. 1, 2.
,, ,, Forbes and Hanley, 1853. Hist. Brit. Moll., iii, p. 408, pl. cix, figs. 1, 2.
Buccinopsis ,, Jeffreys, 1867. Brit. Conch., iv, p. 298, pl. v, fig. 3; v, pl. lxxxiii.

Jeffreys gives several localities on the authority of others; for instance, west coast of Ireland, 100 fathoms; soft ground beyond the Doggerbank, Aberdeenshire; places between the Loffenden Isles, the North Cape, 40–50 fathoms, while he dredged it himself from a bottom of fine sand and mud in 72–87 fathoms off the northern and eastern coasts of Shetland.

Not recorded by Locard in either the *Travailleur*, *Talisman*, or *Caudan* expeditions.

Station V. 109 fathoms. One living and two dead, the latter young shells.

Station IX. 240 fathoms. Three young shells dead.
,, XI. 146 fathoms. Two young shells, one living, one dead.
,, XII. 246 fathoms. One young shell dead.

TRITONOFUSUS, Beck.

(1) **Tritonofusus gracilis** (da Costa).

Buccinum gracile, da Costa, 1778. Brit. Conch., p. 124, pl. vi, fig. 5.

Fusus gracilis, Alder, 1848. Cat. Moll. North. and Dur., p. 63.

Neptunea gracilis, P. Fischer, 1878. In Act. Soc. Lin., Bord., xxxii, p. 190.

Distribution, Norway, Sweden, the seas of Northern Europe pretty generally. Locard is of the opinion that its reputed discovery in the Mediterranean requires confirmation.

I am, to some extent, doubtful as to the identification of all the specimens I have referred as belonging to this species, their condition not being good in most cases.

Station I. 75 fathoms. One of average size but long dead, one smaller, dead and broken.

Station II. 75 fathoms. Two, both dead, one with remnants of epidermis.

Station V. 109 fathoms. Two, both dead, and young shells.

,, IX. 240 fathoms. One of average size but long dead, and one fragment.

(2) **Tritonofusus (Siphonorbis) propinquus** (Alder).

Fusus (*Siphonorbis*) *propinquus*, Alder, 1848. Cat. Moll. North. and Dur., p. 63.

,, ,, ,, Forbes and Hanley, 1853. Hist. Brit. Moll., vol. iii, p. 419, pl. 103, fig. 2.

I cannot find much recorded relating to the distribution of this species, and the *Porcupine* material has not yet been worked out. Jeffreys' localities, given in his *British Conchology*, are all Northern or Irish Sea, and Dautzenberg records it from the coast of Loire-Inférieur. I do not find it mentioned as having been found by the *Caudan*, *Travailleur et Talisman*, or the Prince of Monaco's expeditions.

Station V. 109 fathoms. One young, dead.

,, IX. 240 fathoms. One living.

,, XI. 146 fathoms. One dead embryonic, one dead but covered with epidermis.

(3) **Tritonofusus turritus** (Sars).

Tritonium turritum, Sars, 1858. Arct. Moll. Norg. in Vet. Forh. Christ., p. 39.

Fusus propinquus, var. turrita, Jeffreys, 1867. Brit. Conch., iv, p. 339.

Distribution, Norway, etc., and according to Jeffreys, in 78 fathoms off the coast of Shetland. Locard does not record this species from either the *Travailleur* and *Talisman* or *Caudan* expeditions.

Station XIII. 246 fathoms. One living and one dead.

(4) **Tritonofusus (Siphonorbis) jeffreysianus** (Fischer).

Fusus Jeffreysianus, P. Fischer, 1868. In Journ. Conch., xvi, p. 37,

Neptunia Jeffreysiana, P. Fischer, 1878. In Act. Soc. Lin., Bordeaux, xxxii, p. 198.

Sipho Jeffreysiana, Tryon, 1881. Man. Conch., part x, p. 126, pl. 41, fig. 308.

Neptunia Jeffreysiana, Locard, 1896. Campagne du *Caudan*, facic. i, pl. v., fig. 6.

Locard remarks that this species is very local in its distribution, it being more or less confined to the Bay of Biscay, the commonest form of the French coast.

It was dredged in the *Porcupine*, *Travailleur*, 1882, *Hirondelle*, 1886, *Caudan*, 1895, expeditions in the Bay of Biscay.

Station V. 109 fathoms. Two living, both males. One dead, young and broken.
,, IX. 240 fathoms. One dead.

(5) **Tritonofusus fusiformis** (Broderip).

Buccinum fusiforme, Broderip, 1829. In Zool. Journ., v, p. 45, pl. iii, fig. 3.

Fusus fenestratus, Turton, 1832. In Ann. Mag. Nat. Hist., vii, p. 351.

Neptunea fenestrata, Kobelt, 1875. In Martini und Chemnitz, Conch. Cab., 2e édit., p. 97, pl. xxvi, fig. 6.

Sipho fusiformis, G. O. Sars, 1878. Moll. reg. arct. Norvegiæ, p. 377, pl. xiv., fig. 1.

Neptunea (*Siphonorbis*) *fusiformis*, Friele, 1879. Norsk. Nordh. Exped., Buccin, p. 18.

Sipho (*Siphonorbis*) *fusiformis*, Ed. Smith, 1889. In Ann. Mag. Nat. Hist., 6e sér., p. 424.

This species seems to be widely distributed in the North Atlantic, from Scandinavia and Finmark to the coasts of Morocco. Mons. Locard points out that in the north it inhabits comparatively shallow water, living at greater and greater depths as its most southern recorded habitat is reached.

Station V. 109 fathoms. One dead.
,, IX. 240 fathoms. One young, living.
,, XII. 246 fathoms. One dead.

NOTE.—At first I concluded that specimens from Stations 9 and 12 were referable to *Neptunea peregra*, Locard (*Exped. du Trav. et du Talis., vol. i, p.* 371, *pl. xviii, figs.* 8 *to* 11). I submitted them to Mons. Dautzenberg, who decided they were the young of the above species. Is *Neptunea peregra*, Locard, a distinct species?

FASCIOLARIIDÆ.

BUCCINOFUSIS (Conrad).

Buccinofusus berniciensis (King).

Fusus berniciensis, King, 1846. In Ann. and Mag. Nat. Hist. xviii, p. 246.

Boreofusus berniciensis, G. O. Sars, 1878. Moll. Reg. Arct. Norvegiæ, p. 278.

Troschelia berniciensis, Friele, 1882. Norske Nord. Exped. i, p. 26.

Neptunia berniciensis, Locard, 1886. Prodr. Conch. Franc., p. 176.

Dredged at various stations, in deep water, from the North of Spain to Cape Verde, also by Mr. Holt of the Irish Board of Agriculture, in 337 fathoms, 48 miles to the N.W. of Tearaght, Co. Kerry, 1904. It has been recorded from several localities in the British area, Norway, Faröe Islands, North Russia and Davis Straits.

Station IX. 240 fathoms. One dead, in very poor condition.

PSEUDOMUREX, Monterosato.

Pseudomurex richardi (P. Fischer).

Murex richardi, P. Fischer, 1882. In Journ. Conch., xxx, p. 49.

Pseudomurex richardi, Monterosato, 1890. Coq. Prof. Palermo, p. 23.

Distribution: In deep water from the Bay of Biscay to the west coast of Morocco and in the Mediterranean.

Station XIII. 412 fathoms. Two living.

MURICIDÆ.

TROPHON, Montfort.

Trophon muricatus (Montagu).

Murex muricatus, Montagu, 1803. Test. Brit., p. 262, pl. ix, fig. 2.

Fusus echinatus, Philippi, 1836. Enum. Moll. Sicil., I, p. 206, pl. xi, fig. 10.

Trophon muricatus, Forbes and Hanley, 1853. Hist. Brit. Moll., iii, p. 439, pl. cxi, figs. 3, 4.

Trophon (*Trophonopsis*) *muricatus*, Buquoy and Dautzenberg, 1882. Moll. Rous., I, p. 39, pl. vi, fig. 7.

Generally distributed in European seas as far north as Belgium and south to the Mediterranean and Ægean seas. The single specimen found falls in with Locard's remarks as to the small size of the dredged examples, it being only 10·5 millimetres in height.

Station V. 109 fathoms. One (young) dead.
,, XI. 146 fathoms. One dead.

COLUMBELLIDÆ.

ANACHIS, H. and A. Adams.

Anachis costulata (Cantraine) auct.

Fusus costulatus, Cantraine, 1835 (?). Diagn. Esp. Nouv. in Bull. Acad., Bruxelles, p. 20.

Columbella haliœti, v. albula, Jeffreys, 1867. Brit. Conch., iv, p. 356, pl. vi, fig. 5. ; 1869, v, p. 219, pl. lxxxviii, fig. 3.

Bela grimaldi, Dautzenberg, 1889. Contrib. Faune Malac., Açores, p. 26, pl. ii, figs. *2a, 2b, 2c, 2d.*

Bela limatula, Locard, 1896. Résultats Scient. de la Camp. du *Caudan*, Mollusques, p. 141, pl. v, fig. 3.

I submitted the two specimens to Mons. Dautzenberg, having in vain endeavoured to trace them in the National Collection or figured and described in the above-mentioned works, neither Locard's or Dautzenberg's figures showing the teeth on the outer lip, both having been drawn from young shells.

This species must be widely distributed in the North Atlantic, though the records are few.

Station XII. 146 fathoms. Two dead shells.

OPISTHOBRANCHIA.

TECTIBRANCHIA.

BULLACEA.

SCAPHANDRIDÆ.

SCAPHANDER, de Montfort.

Scaphander lignarius (de Montfort).

Bulla lignaria, Linné, 1758. Sys. Nat., édit. x, p. 727.

Scaphander lignarius, de Montfort, 1810. Conch. Syst., ii, p. 334.

Bulla lignaria, Gray, 1815. In Ann. Phil., p. 408.

Very widely distributed on the coasts of Europe, from Norway to throughout the Mediterranean, in shallow and deep water.

Station V. 109 fathoms. One large living and one smaller, dead.
,, XI. 146 fathoms. One fragmentary, dead.
,, XII. 246 fathoms. One small and broken.

CAVOLINIIDÆ.

Clio, Linné.

Clio pyramidata, Linné.

Clio pyramidata, Linné, 1767. Syst. Nat., 12th Ed., p. 1094.

Hyalœa lanceolata, Lesueur, 1813. Nouv. Bull. Soc. Philom. de Paris, iii, p. 284, pl. v, fig. 3.

This species has many synonyms, whose repetition is hardly necessary.

It is cosmopolitan in its distribution throughout the oceanic world.

Station XII. 246 fathoms. Thirteen specimens, more or less fragmentary, though two or three contained the animal in a much contracted state.

Cavolinia, Abildgard.

(1) **Cavolinia trispinosa** (Lesueur).

Hyalœa trispinosa, Lesueur, 1821. In de Blainville, Dict. Hist. Nat., xii, p. 82.

Hyalœa mucronata, Quoy and Gaymard, 1827. In Ann. Sci. Nat., x, p. 231, pl. viii, B.

Hyalœa depressa, Bivona, 1832. Ejemer. Scient. Sicil., pl. ii, figs. 4, 5.

Cavolinia trispinosa, Locard, 1886. Prodrom. Conch. Franc., p. 22.

Cavolinia (*Diacria*) *trispinosa*, Dall, 1889. In Bull. United States Nat. Mus., xxxvii, p. 82, pl. lxvi, fig. 115.

I have compared our solitary, nearly perfect specimen with those from the Atlantic in the British Museum (Nat. Hist.).

This species is widely distributed, and is recorded from the east and west coasts of the Atlantic, the Mediterranean, West Indies, Madeira and Canary Isles, and Pacific Ocean.

Station XII. 246 fathoms. One dead and one fragment.

(2) **Cavolinia inflexa** (Lesueur).

Hyalœa inflexa, Lesueur, 1813. Nouv. Bull. Soc. Philom., vol. iii, p. 285, pl. v, fig. 4, A—D.

Hyalœa labiata, d'Orbigny, 1836. Voyage dans l'Amerique Meridionale, vol. v, p. 104, pl. vi, figs. 21–25.

Cavolinia inflexa, Tesch., 1904. The *Thecosomata* and *Gymnosomata* of the Siboga Expedition, p. 43, pl. ii, figs. 54–63.

This is a very variable species and has extensive synonymy: our two shells seem to be referable to *v. labiata* from an examination of those so named in the British Museum (Nat. Hist.).

Station XII. 246 fathoms. Two empty shells.

PLEUROBRANCHACEA.

PLEUROBRANCHIÆ.

PLEUROBRANCHUS, Cuvier.

Pleurobranchus, Sp.

I have submitted this specimen to Sir Charles Eliot, who remarks, "an immature *Pleurobranchus*, very likely *P. plumula*, Montagu; but the dorsal skin has been torn off. The species cannot be identified."

Station XIII. 412 fathoms.

NUDIBRANCHIA.

KLADOHEPATICA.

ÆOLIDIIDÆ.

Genus?

Sir Charles Eliot remarks, "The body of an Æolid which has lost all but its papillæ and is otherwise in poor preservation. It is not possible to determine even the genus."

Station VII. $\dot{\overline{444}}$ fathoms.

DOTONIDÆ.

DOTO, Oken.

Doto, Sp.

Sir Charles Eliot remarks, "A *Doto*, probably *D. fragilis*, Forbes." It is common on the British coasts, and is very likely generally distributed in the Atlantic.

Station II. 75 fathoms.

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LIST OF SPECIES, AND THE STATIONS AT WHICH THEY OCCUR.

Station No.	British Species	I	II	IV	V	VI	VII	IX	XI	XII	XIII
Latitude, N.		48° 25′	48° 24′	47° 48′	47° 48′	47° 46′	47° 36′	48° 7′	48° 10′	43° 7′	48° 7′
Longitude, W.		6° 28′	6° 28′	7° 25′	7° 46′	7° 12′	7° 31′	8° 13′	8° 11′	8° 13′	8° 13′
Fathoms		75	75	109	109	87	444	240	146	246	412
Amphineura.											
1. Rhopalomenia aglaopheniæ	+	+	...	...	...	...	...	...	...	...	+
Pelecypoda.											
2. Nucula sulcata	+	...	...	...	...	...	...	+	...	...	...
3. ,, nitida	+	...	...	...	...	...	...	...	...	+	...
4. Anomia ephippium	+	...	...	...	...	...	...	+	+	+	...
5. Limopsis aurita	+	...	...	+	...	...	...	+	...	+	...
6. ,, minuta	+	...	...	...	...	...	...	...	...	+	...
7. Glycymeris glycymeris	+	+	...	...	+	...	...	...	...	...	...
8. Arca nodulosa	+	...	...	...	...	...	+	...	...	...	+
9. ,, obliqua	+	...	...	...	+	...	...	...	...	...	...
10. Volsella phaseolina	+	...	+	...	...	...	...	...	...	...	...
11. Pecten bruei	+	...	...	...	...	...	...	...	...	...	+
12. Chlamys sulcatus	+	...	...	...	...	...	...	+	...	...	...
13. Æquipecten opercularis	+	+	+	+	+	...	...	...	+	...	...
14. Palliolum similis	+	...	...	...	+	...	...	...	...	...	...
15. ,, vitreus	+	...	...	...	...	...	+	...	...	...	+
16. Lima excavata	...	...	...	...	...	...	+	...	...	...	...
17. ,, marioni	...	...	...	...	...	...	+	...	...	...	+
18. ,, subauriculata	+	...	...	...	+	...	...	...	...	...	...
19. Astarte sulcata	+	+	+	...	...	...	...	+	...	+	+
20. Syndosmya prismatica	+	...	+	...	...	...	...	...	+	...	...
21. Spisula elliptica	+	+	+	...	+	...	...	...	+	...	...

LIST OF SPECIES, AND THE STATIONS AT WHICH THEY OCCUR—*continued.*

STATION NO.		I	II	IV	V	VI	VII	IX	XI	XII	XIII
Latitude, N. / Longitude, W.		48° 25′ / 6° 28′	48° 24′ / 6° 28′	47° 48′ / 7° 25′	47° 48′ / 7° 46′	47° 46′ / 7° 12′	47° 36′ / 7° 31′	48° 7′ / 8° 13′	48° 10′ / 8° 11′	48° 7′ / 8° 13′	48° 7′ / 8° 13′
Fathoms		75	75	109	109	87	444	240	146	246	412
	BRITISH SPECIES										
Pelecypoda—*continued.*											
22. Lucinopsis undata	+	...	...	...	+	...	...	...	...	...	...
23. Venus casina	+	+	...	+	+	...	...	...	...	...	...
24. ,, ovata	+	+	+	...	+	...	...	...	+	+	...
25. Gouldia minima	+	...	...	...	+	...	...	...	...	...	...
26. Cardium minimum	+	...	...	...	...	...	...	+	...	...	...
27. Lævicardium norvegicum	+	...	...	+	...	...	...	...	...	...	...
28. Gari costulata	+	...	...	...	+	...	...	...	...	...	...
29. Saxicava arctica	+	+	+	...	...	...	...	...	...	...	...
30. Pandora inæquivalvis	+	...	...	...	+	...	...	...	...	...	...
31. Lyonsia norvegica	+	+	...	...	...	...	...	...	...	...	...
32. Thracia papyracea	+	...	...	...	+	...	...	...	...	...	...
33. Cuspidaria abbreviata	+	...	...	...	...	...	...	...	...	+	...
34. ,, cuspidata	+	...	...	...	...	...	...	...	+	+	...
35. ,, curta	+	...	...	...	...	...	...	...	...	+	...
Scaphopoda.											
36. Dentalium entalis	+	+	...	...	+	...	...	+	+	...	...
37. ,, panormitianum	+	...	...	...	...	...	...	+	.	...	...
Gastropoda.											
38. Puncturella noachina	+	...	...	...	...	...	...	...	...	+	...
39. Emarginula fissura	+	+	...	...	...	...	...	...	...	...	...

Gastropoda—*continued.*

40. Emarginula multistriata	...	...	...	...	...	...	+	...	...	...	...
41. Calliostoma obesulum	...	...	...	...	...	...	+	...	...	...	+
42. ,, cleopatra	...	...	...	...	...	...	+	...	...	...	...
43. ,, miliaris	+	+	...	...	...	...	...	...	...	...	...
44. ,, granulatum	+	...	...	...	+	+	...	...	...	...	...
45. Capulus hungaricus	+	...	...	+	...	...	...	...	...	...	...
46. Natica (lunatia) sordida	+	...	...	...	...	...	...	+	...	+	...
47. ,, (,,) catena	+	.	+	...	...	...	...	...	...	...	...
48. ,, (,,) alderi	+	...	...	...	+	...	...	...	+	...	...
49. ,, (,,) montagui	+	...	...	...	+	...	...	...	+	+	...
50. ,, (,,) operculata	...	+	...	...	...	...	...	...	...	...	...
51. Lamellaria perspicua	+	...	...	...	...	+	...	...	...	...	...
52. Ranella gigantea	...	...	...	+	...	...	...	...	...	...	...
53. Scala clathrus	+	+	...	...	...	...	...	...	...	...	...
54. ,, trevelyana	+	...	...	...	...	...	...	...	+	...	...
55. ,, richardi	...	...	...	...	...	...	...	+	...	...	...
56. Turritella communis	+	...	...	...	...	...	...	...	+	...	...
57. Torellia vestita	+	...	...	...	...	...	...	...	...	...	+
58. Buccinum undatum	+	+	+	...	+	+	...	...	...	...	...
59. ,, sp.	...	...	...	...	+	...	...	...	...	...	...
60. Liomesus dalei	+	...	...	...	+	...	...	+	+	+	...
61. Tritonofusus gracilis	+	+	+	...	+	...	...	+	...	...	...
62. ,, (Siphonorbis) propinquus	+	...	..	...	+	...	...	+	+	...	...
63. ,, ,, turritus	+	...	...	...	...	...	...	...	...	+	...
64. ,, ,, jeffreysianus	+	...	...	...	+	...	...	+	...	...	...
65. ,, ,, fusiformis	+	...	...	...	+	...	...	+	...	+	...
66. Buccinofusus berniciensis	+	...	...	...	...	...	...	+	...	...	...
67. Pseudomurex richardi	...	...	...	...	...	...	...	...	...	...	+
68. Trophon muricatus	+	...	...	...	+	...	...	...	+	...	...
69. Anachis costulata	+	...	...	...	...	...	...	...	...	+	...
70. Scaphander lignarius	+	...	...	...	+	...	...	...	+	+	...
71. Clio pyramidata	+	...	...	...	...	...	...	...	...	+	...
72. Cavolinia trispinosa	+	...	...	...	...	...	...	...	...	+	...
73. ,, inflexa	...	...	...	...	...	...	...	...	...	+	...
74. Pleurobranchus sp.	...	...	...	...	...	...	...	...	...	...	+
Nudibranchia.											
75. Doto sp.	+	...	+	...	...	...	...	...	...	...	...

The Brachiopoda collected by the "Huxley" from the North Side of the Bay of Biscay, in August, 1906.

By

Alexander Reynell.

Of the three species of Brachiopoda found, two, *Magellania cranium* and *M. septigera*, are found in the British list. The third species, *Mühlfeldtia truncata*, has not, as far as I can discover, previously been recorded from so high a latitude, Turton's Torbay locality being very doubtful.

BRACHIOPODA.

ARTICULATA.

TEREBRATULIDÆ.

Magellania, Bayle.

(1) **Magellania cranium**, Müller.

Terebratula cranium, Müller, 1776. Zool. Dan. Prodr., p. 249.

Anomia cranium, Gmelin, 1789. Syst. Nat., édit. xiii, p. 3347.

Waldheimia cranium, Reeve, 1860. Conch. Icon., pl. iii, fig. 6.

Magellania (*Macandrevia*) *cranium*, P. Fischer et Œhlert, 1891. *Trav.* and *Talis.* Expedit., Brach., p. 73, pl. v, figs. 10*a*–10*s*.

Distributed from Greenland and Norway to the south-west of France, according to Jeffreys. A. Adams records it from Northern Asia and Japan.

Mons. Dautzenberg kindly identified this species.

Station V. 109 fathoms. One living.
,, XII. 246 fathoms. One living.

(2) **Magellania septigera**, Lovén.

Terebratula septigera, Lovén, 1846. Index Moll. Scand., p. 29.

Waldheimia septigera, Davidson, 1855. Ann. and Mag. Nat. Hist. [II], vol. xvi, 1855.

Terebratula septata, Jeffreys, 1878. Proc. Zool. Soc., London, p. 407, pl. xxiii, fig. 1.

There seems to be some doubt as to whether this species is the same as the *Terebratula septata* of Philippi. Both Jeffreys and Locard are of the opinion that it is, but Fischer and Œhlert do not even mention Philippi's name. I, under the circumstances, think it the wisest plan to follow the latter authorities. This species seems to be distributed in the eastern part of the North Atlantic, from Norway and the Hebrides and Shetland Islands to the West Coast of Africa and the Canary Islands.

Station XI. 146 fathoms. One small, living.

„ XIII. 412 fathoms. Eleven living.

Mühlfeldtia, Bayle.

Mühlfeldtia truncata (Linné).

Anomia truncata, Linné, 1767. Syst. Nat., édit. xii, p. 1152, No. 229.

Terebratula truncata, Philippi, 1836. Enum. Moll. Sicil., I, p. 95, pl. vi, fig. 12.

Mühlfeldtia truncata, P. Fischer and D. P. Œhlert, 1891. *Trav. et Talis.* Brachiopoda, p. 80, pl. vii, figs. 11*a*–11*t*.

This species is recorded as being very common in the Mediterranean, and has been found in the Bay of Biscay, at many stations off Cape Finisterre, the North of Spain, and has been dredged off the Morocco coast, and the Canary Isles. Turton's record of a specimen from Torbay is generally considered doubtful, as far as being a proof of its living in the British area is concerned.

Station VII. 144 fathoms. Three living.

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Locard, A.—Brachiopods. Résultats Scientifiques de la Campagne du *Caudan* dans le Golfe de Gascogne, August–September, 1895, 1896.

Many Brachiopods are, of course, included in the older works dealing with the Mollusca as detailed in the bibliography of that group on pages 387 and 388.

Mackerel and Sunshine.

By

E. J. Allen, D.Sc.,

Director of the Marine Biological Association.

With Figs. 1–5 in the Text and Tables I.–VII. at the end.

In his paper on "Plankton Studies in Relation to the Western Mackerel Fishery," in the last number of this Journal (Vol. VIII., p. 269), G. E. Bullen shows that for the years 1903–1907 there appears to be a correlation between the number of mackerel taken during May and the amount of Copepod plankton, upon which the mackerel feed, taken in the neighbourhood of the mackerel fishing grounds during the same month.

It was clearly worth while, therefore, to consider what conditions favour the production of an abundant supply of Copepods in the fishing area, since it appears to be this supply of food which attracts the mackerel into that area, or at any rate into its surface waters.

The hydrographical investigations carried out at the mouth of the English Channel have rendered it probable that the movement of the water there is comparatively slow. It may therefore be assumed that on the mackerel grounds to the westward of the Cornish coast the water which is present at any particular time has not recently moved into the district from any very remote region, and, treating the matter broadly, has been subjected for some time to the general climatic conditions of the neighbourhood.

The question then suggests itself, can the differences which occur from year to year in the abundance of the Copepods be referred in any way to such climatic conditions? If such a connection exists it will probably be not direct, but indirect, through the action of the climatic conditions on the food of the Copepods. The food of Copepods seems to be largely the vegetable organisms of the plankton, chiefly diatoms and Peridinidæ,*

* This has long been recognised in a general way, but useful direct evidence of it has recently been brought forward by W. J. Dakin. *Notes on the Alimentary Canal and Food of the Copepoda. Internat. Revue der gesam. Hydrobiologie u. Hydrographie*, I., 1908.

though even if a considerable proportion of it were found to consist of minute animal organisms, these in their turn would feed upon the phytoplankton. It is therefore to the conditions which favour the production of phytoplankton, the fundamental food supply, that we must turn.

The three most obvious matters to be considered in connection with the production of this vegetable plankton are: (1) the composition of the sea-water itself, (2) the temperature, and (3) the amount of light which is available for the production of plant life.

With regard to the composition of the sea-water itself, the only information available refers to its salinity, and up to the present it has not been possible to show any simple relation between changes in salinity and changes in the vegetable or animal production in the area under consideration. The same is true of temperature, though this will be considered in more detail below.

It is the object of the present paper to call attention to what appears to be evidence of the influence of the third factor, the intensity of light. Experiments on the cultivation of marine plankton diatoms in the laboratory, upon which I had been engaged, had drawn my attention to the great importance to be attached to the intensity of the light to which the diatoms were exposed. It therefore occurred to me that a special abundance of Copepods during the month of May in any year might be due to a special amount of sunshine during the earlier months of the year, which would increase the amount of phytoplankton, the Copepod food. An attempt was therefore made to correlate the average quantity of mackerel per boat taken in May with the number of hours of bright sunshine recorded during the first quarter of the year.

The official statistics of mackerel landed are not very satisfactory for such a purpose, since they give only the total quantities of fish and give no information as to the number of vessels from which the fish are obtained. In making use of them, therefore, one must bear in mind that the number of vessels to which the figures relate varies from year to year, although the amount of this variation over a small number of consecutive years will not generally be very large.

In order to get figures of a more definite character, I applied to Messrs. Peacock & Co., of Lowestoft, who have had vessels engaged in the western mackerel fishery for many years. Messrs. Peacock were good enough to furnish me with a series of figures giving the number of hundreds of mackerel landed each month from February to June, at Newlyn and Milford,* by three of their steam drifters, for each of the

* These vessels landed fish only at Newlyn and Milford, so that, by combining the figures for the two ports, we get the total number of fish taken by each boat from the western fishing grounds.

years 1902–1908, as well as similar figures for three sailing drifters. These figures are given in Tables I. and II.

Messrs. Peacock's figures show that by far the largest quantities of mackerel are landed in the month of May, and that, as in the case of the official statistics (cf. Bullen, *loc. cit.*, p. 277), the figures representing the May landings dominate the curve representing the total landings from the spring fishing. Moreover, it is practically certain that the vessels fished throughout May, whereas for the other months, except, perhaps, April, one has not generally any definite knowledge as to when they began or ended their fishing.

In the diagram below (Fig. 1) the average number of mackerel per

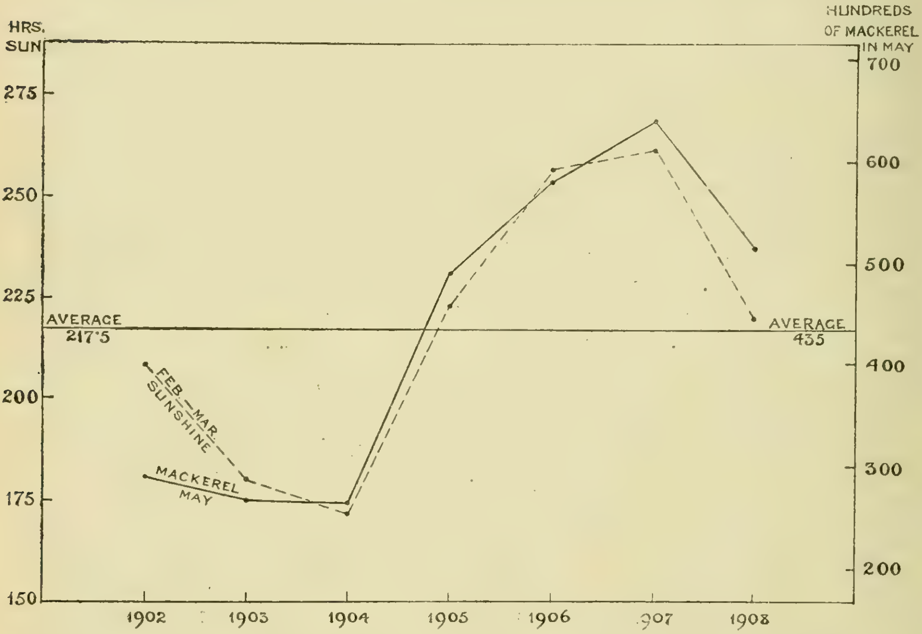

FIG. 1.—The dotted line indicates the average number of hours of bright sunshine recorded for the months of February and March, in each of the years 1902–1908, at the meteorological stations at Plymouth, Falmouth, and Scilly.

The continuous line indicates the average number of "hundreds" (120 fish) of mackerel per boat landed at Newlyn and Milford in the month of May of the same years 1902–1908, by three steam drifters belonging to Messrs. Peacock & Co., of Lowestoft.

boat in "hundreds" (each "hundred" really means 120 fish) landed in May by Messrs. Peacock's three steam drifters is represented by the continuous line, whilst the number of hours bright sunshine during February and March is represented by the dotted line. The sunshine figures were obtained by taking the average of the number of hours

recorded at the three meteorological stations, Plymouth, Falmouth, and Scilly. Although the extreme closeness of the agreement between the two curves may be due to chance, it seems scarcely possible to doubt that they indicate a fundamental correlation between the abundance of mackerel in May and the amount of bright sunshine during the earlier months of the year. The sunshine curve, it should be added, has practically the same shape, whether it is taken for the three stations chosen, or for the whole south-western district of England, which includes inland stations, or for the south-west of England and south Ireland combined. The figures on which the sunshine curve is based will be found in Table III.

In Fig. 2 the continuous line gives the total number of cwts. of mackerel landed on the south and west coasts of England and Wales in May* for each of the years from 1886–1908, as given by the official statistics of the Board of Trade and Board of Agriculture and Fisheries (see Table IV.), whilst the dotted line gives the average number of hours bright sunshine recorded for the south-west of England and south Ireland for the first quarter of the year (Jan.–March), as given in the reports of the Meteorological Office (see Table V.). As already pointed out, the official figures of mackerel landed take no account of the number of boats fishing, and those taken during the first four or five years are known to be very imperfect and should therefore be neglected. It is practically certain that the fishing power has increased during the years for which the records are given, more especially since the introduction of steam drifting about 1902. Comparing the two curves in Fig. 2 generally, and bearing in mind the above limitations, there is, I think, sufficient similarity in the way in which they rise and fall together to justify us in regarding them as in no way contradicting the very definite agreement shown between Messrs. Peacock's figures and the sunshine curve as seen in Fig. 1.

Considering in more detail the years 1902–1908, it will be seen that the most striking difference between the curve given by the official figures and that representing the averages for Messrs. Peacock's boats is the great drop which the official figures show in 1906. A similar though less marked drop in 1906 is also shown by the curve given in Fig. 3, which represents the average number of "hundreds" of mackerel landed by Messrs. Peacock's three sailing drifters. A reference to the figure given by Bullen (*loc. cit.*, p. 279, Fig. 1) also shows a minimum in 1906 for the Copepods taken at the International Stations E.5. and E.6. The high figure for 1906 given by the three steam drifters, although it agrees with the high February and March sunshine for that

* Most of the fish are landed at Newlyn and Milford Haven.

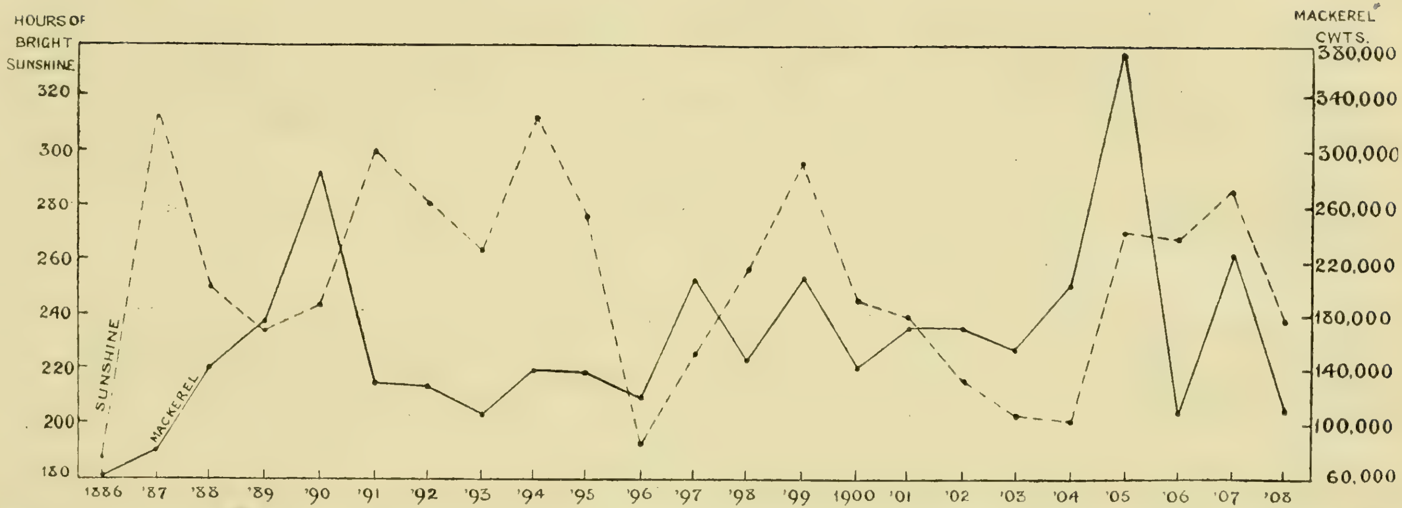

FIG. 2.—The dotted line indicates the average number of hours of bright sunshine recorded for the first quarter of the year (January to March) for each of the years 1886–1908, for the Meteorological Office Districts England S.W. and S. Wales, and Ireland South.

The continuous line indicates the number of hundredweights of mackerel recorded as landed on the South and West Coasts of England and Wales, in the month of May, for each of the years 1886–1908 (Official Statistics).

year, does not therefore agree with the official figures for mackerel, with the catches of the three sailing drifters, nor with the figure taken to represent the Copepods. Any explanation of this discrepancy can only be of a speculative kind, but it is probable that the steam drifters fished much further west of the Scillies than the sailing drifters would go, or than the International Stations are situated. If this is the explanation of the difference shown, it would seem to suggest that in May, 1906, there was some local factor at work on the grounds nearer the shore which did not operate on those which were more distant.

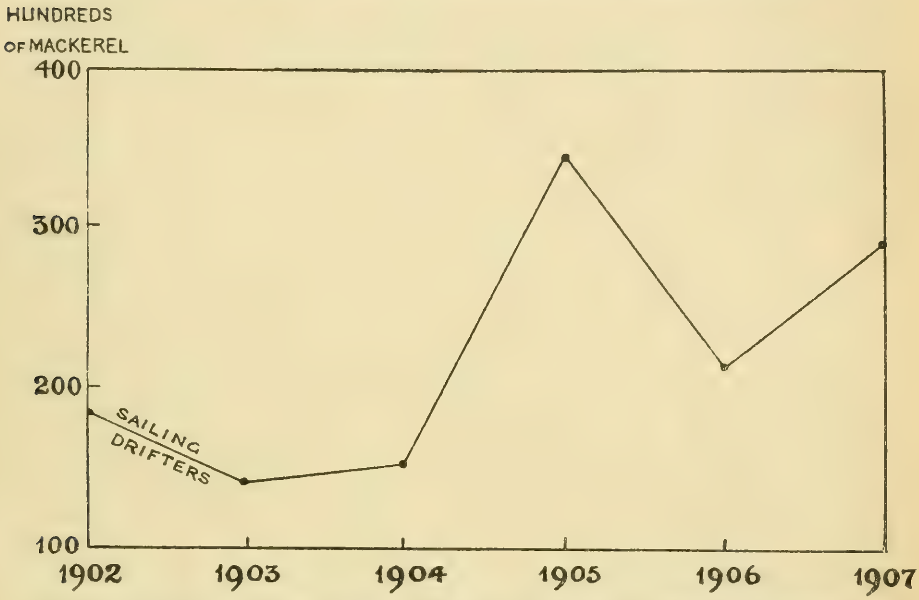

FIG. 3.—Curve indicating the average number of "hundreds" (120 fish) of mackerel per boat, landed at Newlyn and Milford, in the month of May of the years 1902–1907, by three sailing drifters belonging to Messrs. Peacock & Co., of Lowestoft.

Before leaving the question of sunshine it should be stated that curves representing the bright sunshine in the months of April and May have not shown any kind of correlation with the quantities of mackerel taken.

In order to ascertain whether the temperature of the water during the fishing months in the different years bore any relation to the takes of mackerel, and to meet the suggestion that the effect of the bright sunshine might have been simply to increase that temperature, a series of curves have been drawn showing the average temperature of the surface water in February, March, April, and May for each of the years 1902–1908 in the area between 48° and 50° North Latitude and 4° and 10° West Longitude. The temperatures given in Table VI., and

represented in Fig. 4, are the means of the six temperature averages given for this area on the Monthly Pilot Charts of the North Atlantic, issued by the Meteorological Office in London. For comparison with these, Table VII., and Fig. 5 give the mean temperatures at the surface and at 10 meters (5 fathoms) depth found at Stations E.5. and E.6. on the International Cruises carried out in May in each of the years 1903–8. It will be seen that the two curves follow the same general course. The outstanding feature of these temperature curves is the occurrence of two very marked maxima in 1903 and 1905. On

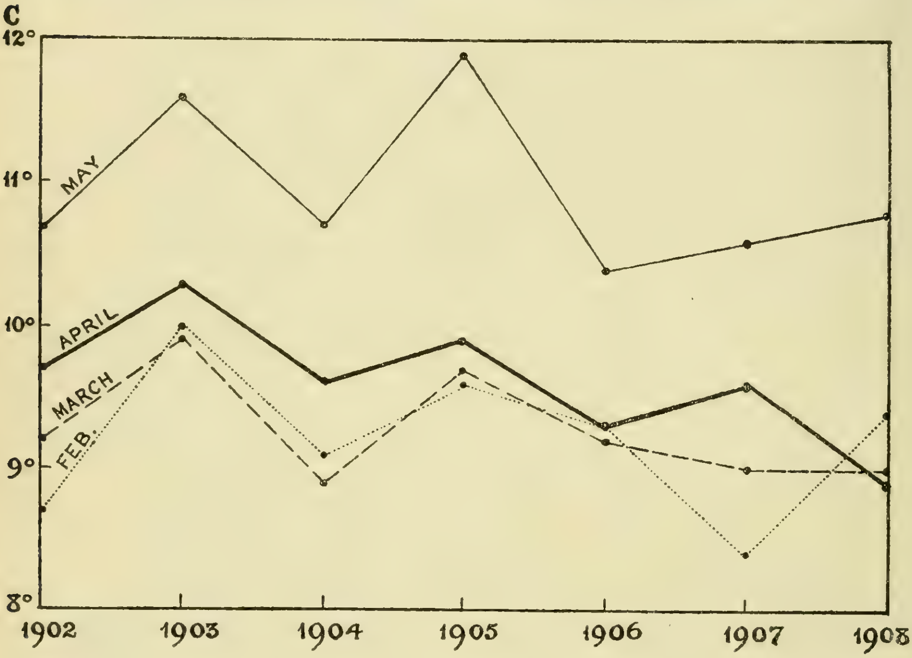

FIG. 4.—Curves showing the mean surface temperature of the sea in degrees Centigrade in the area between Lat. 48° and 52° N., and Long. 4° and 10° W., as given on the Monthly Pilot Charts of the Meteorological Office for the months of February, March, April, and May, in the years 1902–1908.

comparing the curves with the curves representing the catches of mackerel, either with that given by Messrs. Peacock's figures, or by the official figures, no relation between the two can be traced. Whilst the 1905 temperature maximum agrees with the maximum total catch of mackerel as shown by the official statistics and the high average catch shown by Messrs. Peacock's figures, the temperature maximum of 1903 is accompanied by low catches of mackerel. The other parts of the curves also give no indication of any close connection between the surface sea temperatures and the mackerel catches.

I have to thank Mr. G. E. Bullen for assistance in plotting the early curves which rendered the relation between sunshine and mackerel probable, though I am myself entirely responsible for the accuracy of the curves and figures as given in this paper. Mr. D. J. Matthews has also helped me in various ways.

My thanks are especially due to Messrs. Peacock & Co., of Lowestoft, for the very great trouble they have taken in supplying the figures showing the numbers of mackerel caught by their vessels and for allowing them to be used. Without their ready co-operation this paper could not have been written.

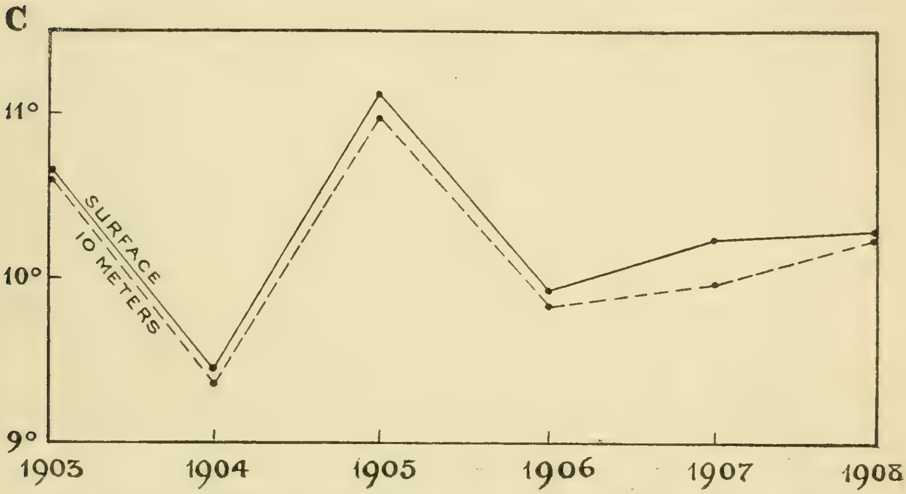

Fig. 5.—Curves showing the means of the temperatures, in degrees Centigrade, recorded at Stations E.5 and E.6 at the surface (continuous line) and at 10 meters (dotted line), on the International Investigation Cruises in the month of May, for the years 1903–1908.

TABLE I.

Table showing the number of "hundreds" of Mackerel landed by three STEAM DRIFTERS at Newlyn and Milford Haven for the years 1902–8, from figures supplied by Messrs. Peacock & Co., of Lowestoft.

	LANDED AT NEWLYN.			LANDED AT MILFORD.			Average Number of 'hundreds' per boat landed at Newlyn and Milford.
	Steam drifter A.	Steam drifter B.	Steam drifter C.	Steam drifter A.	Steam drifter B.	Steam drifter C.	
1902.	Hds.	Hds.	Hds.	Hds.	Hds.	Hds.	Hds.
March . .	—	222½	18	—	—	—	120
April . .	103¾	263¾	134½	—	—	—	201
May . .	490½	263	113½	—	—	—	289
June . .	287	289½	—	—	—	—	288
1903.							
March . .	247½	127¼	409¼	—	—	—	261
April . .	120¼	140¾	202	—	—	24½	162
May . .	328½	218	196½	—	—	60¾	268
June . .	117½	57½	47	—	—	—	74
1904.							
March . .	300¼	347½	237¼	—	—	—	295
April . .	111¾	216¾	313½	—	—	34	225
May . .	293¾	293	197½	—	—	—	261
June . .	277½	143	—	—	—	—	210
1905.							
February .	—	19½	—	96	49¼	12½	59
March . .	120½	182	374¼	98½	87¼	25	296
April . .	235¾	—	291¼	—	429¾	—	319
May . .	585	37	470¼	—	378¾	—	490
June . .	47½	—	—	—	—	—	47
1906.							
February .	—	—	—	4	—	—	—
March . .	27½	16	12½	4	111¾	12¼	61
April . .	110½	62	129¼	—	83½	—	125
May . .	269	767	708½	—	—	—	581
June . .	29	—	21	—	—	—	25
1907.							
March . .	160¼	9¼	48¼	—	32¼	—	83
April . .	105¼	320¼	105¼	—	4¼	—	178
May . .	457	869	584¾	—	—	—	637
June . .	—	—	—	—	—	—	—
1908.							
March . .	109½	66¼*	37†	—	—	—	71
April . .	363¾	266	326¼	—	—	—	319
May . .	418	616¾	237¾¶	—	—	—	517††
June . .	—	—	—	—	—	—	—

* Steam drifter B is not the same vessel in 1908 as in previous years.

† Commenced March 17th.

¶ Finished May 19th.

†† Average for vessels A and B.

TABLE II.

Table showing the number of "hundreds" of Mackerel landed by three SAILING DRIFTERS at Newlyn and Milford Haven for the years 1902–7, from figures supplied by Messrs. Peacock & Co., of Lowestoft.

	LANDED AT NEWLYN.			LANDED AT MILFORD.			Average Number of 'hundreds' per boat landed at Newlyn and Milford.
	Sailing drifter A.	Sailing drifter B.	Sailing drifter C.	Sailing drifter A.	Sailing drifter B.	Sailing drifter C.	
1902.	Hds.	Hds.	Hds.	Hds.	Hds.	Hds.	Hds.
March . .	1½	9	—	—	—	—	5
April . .	57¼	241	129½	—	—	—	144
May . .	—	150½	215½	—	—	—	183
June . .	—	—	113	—	—	—	113
1903.							
March . .	1¼	53½	—	—	—	—	27
April . .	83¼	160	77½	—	—	—	107
May . .	93¼	—	123¼	—	202	—	139
June . .	88	57½	166¾	—	—	—	104
1904.							
March . .	—	31	10¾	—	594	—	318
April . .	19	—	47½	—	86	—	51
May . .	187	107	143½	—	35	—	157
June . .	113	81½	103¾	—	—	—	99
1905.							
March . .	—	—	162½	—	240	—	201
April . .	42¾	—	237¼	—	265¾	—	182
May . .	259¼	250	457¾	—	70	—	346
June . .	52½	—	—	—	—	—	52½
1906.							
March . .	19¼	—	6½	—	12½	—	13
April . .	226¾	—	157¼	—	151	—	178
May . .	90	—	111½	—	443	—	215
June . .	—	10½	—	—	—	—	10½
1907.							
March . .	56¼	—	—	—	15½	—	36
April . .	240½	64	148¾	—	80½	—	178
May . .	—	58	260	—	266½	—	292
June . .	—	—	—	—	—	—	—

TABLE III.

Table showing the average number of hours of Bright Sunshine recorded at the three Meteorological Stations, Plymouth, Falmouth, and Scilly, in January, February, and March of the years 1902–8.

	January.	February.	March.	Average for February and March together.
1902.				
Plymouth . .	45·6	92·5	108·4	
Falmouth . .	49·3	87·0	123·3	
Scilly . .	56·5	92·7	121·5	
Average .	50·4	90·7	117·7	208·4
1903.				
Plymouth . .	38·6	59·3	110·8	
Falmouth . .	55·3	63·3	126·7	
Scilly . .	71·5	50·2	129·6	
Average .	51·5	57·6	122·4	180·0
1904.				
Plymouth . .	42·0	52·1	121·5	
Falmouth . .	48·0	57·7	104·7	
Scilly . .	49·6	55·5	123·3	
Average .	46·5	55·1	116·5	171·6
1905.				
Plymouth . .	69·4	81·0	136·6	
Falmouth . .	65·1	88·0	137·7	
Scilly . .	61·7	81·9	146·3	
Average .	65·4	83·6	140·2	223·8
1906.				
Plymouth . .	66·9	96·2	142·9	
Falmouth . .	64·6	110·7	164·8	
Scilly . .	77·9	101·7	154·3	
Average .	69·8	102·9	154·0	256·9
1907.				
Plymouth . .	75	91	186	
Falmouth . .	74	76	178	
Scilly . .	66	69	186	
Average .	72	79	183	262
1908.				
Plymouth . .	72	67	147	
Falmouth . .	49	74	153	
Scilly . .	56	61	158	
Average .	59	67	153	220

TABLE IV.

Table showing the number of hundredweights of MACKEREL landed at Ports on the South and West Coasts of England and Wales in the month of MAY for the years 1886–1908, compiled from official statistics of the Board of Trade and Board of Agriculture and Fisheries.

Year.	*May.* *No of cwts. Mackerel.*	*Year.*	*May.* *No. of cwts. Mackerel.*
1886	... 63,338	1898	... 146,769
1887	... 71,117	1899	... 207,962
1888	... 139,739	1900	... 138,723
1889	... 173,828	1901	... 169,020
1890	... 280,444	1902	... 169,857
1891	... 127,148	1903	... 152,753
1892	... 127,183	1904	... 199,884
1893	... 105,754	1905	... 378,157
1894	... 139,384	1906	... 108,273
1895	... 135,238	1907	... 222,151
1896	... 119,323	1908	... 108,144
1897	... 193,769		

TABLE V.

Table showing the Number of Hours of BRIGHT SUNSHINE recorded over *England S.W. and S. Wales* and *Ireland S.* for the first Quarter of the years 1886–1908. From the records of the Meteorological Office.

Year.		England S.W. and S. Wales. Hours.	Ireland S. Hours.	Mean. Hours.
1886	......	174	203	188
1887	......	314	309	312
1888	......	240	260	250
1889	......	227	243	235
1890	......	239	247	243
1891	......	300	300	300
1892	......	305	257	281
1893	......	285	244	264
1894	......	330	293	312
1895	......	292	260	276
1896	.....	195	190	192
1897	......	215	237	226
1898	......	260	255	257
1899	......	304	286	295
1900	......	234	256	245
1901	......	240	238	239
1902	......	217	215	216
1903	......	205	201	203
1904	......	207	193	200
1905	......	272	268	270
1906	......	286	250	268
1907	......	315	256	286
1908	......	246	229	238

TABLE VI.

Table showing the average surface temperature in degrees Centigrade of the Area between 48° and 52° North Latitude and 4° and 10° West Longitude from February to May, as given on the Monthly Pilot Charts of the Meteorological Office. Each temperature given is the average of six means printed on the charts.

	1902.	1903.	1904.	1905.	1906.	1907.	1908.
February ...	8·7	10·0	9·1	9·6	9·3	8·4	9·4
March ...	9·2	9·9	8·9	9·7	9·2	9·0	9·0
April ...	9·7	10·3	9·6	9·9	9·3	9·6	8·9
May ...	10·7	11·6	10·7	11·9	10·4	10·6	10·8

TABLE VII.

May Hydrographic Cruises.

Temperatures (C°) at Stations E.5 and E.6.

	Surface.			*10 meters.*		
	E.5.	**E.6.**	**Mean.**	**E.5.**	**E.6.**	**Mean.**
1903 . .	11·08	10·20	10·64	11·02	10·19	10·60
1904 . .	9·63	9·30	9·46	9·60	9·15	9·37
1905 . .	11·39	10·83	11·11	11·25	10·71	10·98
1906 . .	10·16	9·68	9·92	10·03	9·62	9·82
1907 . .	10·69	9·79*	10·24	10·63	9·33*	9·98
1908 . .	10·69	9·91	10·30	10·69	9·85	10·27

Station E.5 is situated in Lat. 49° 6′ N., Long. 6° 32′ W.; i.e. about 50 miles to the southward of the Scilly Isles.

Station E.6 is situated in Lat. 50° 24′ N., Long. 6° 5′ W.; i.e. about 30 miles to the northward of the Scilly Isles.

The Temperature records are taken from the *Bulletin des résultats acquis pendant les croisières periodiques.* 1902 onwards.

* Sta. E. 1907. V. 14. 50° 35′ N. Lat., 6° 14′ W. Long., 89 m., worked for E.6. (about 11 miles further north). Probable surface temp. at E.6. would be 0·4° lower.

The Decapoda collected by the "Huxley" from the North Side of the Bay of Biscay in August, 1906.

By

Stanley Kemp, B.A.

THE collection of Decapoda made by the *Huxley* during her short cruise on the north side of the Bay of Biscay is an extensive one; it comprises no less than forty-nine species—a number which speaks well for the efficiency of the gear employed.

Although, as might be expected, the majority of the species obtained are well-known members of the N.E. Atlantic fauna, the material presents many points of interest. Five species not hitherto known to extend south of the British Isles were found by the *Huxley*, and in several cases important additions have been made to our knowledge of the bathymetric range.

A specimen which has been tentatively referred to *Periclimenes Korni* (Lo Bianco) is of the greatest possible interest, for no deep-water representative of the family Palæmonidæ was hitherto known from the N.E. Atlantic. Unfortunately, the species is represented only by a fragment of a single individual; this is particularly irritating, for the collection, as a whole, is in a remarkably good state of preservation.

No close comparison can be made between the species in the present collection and those found by the *Caudan* in 1895, for the latter expedition worked considerably to the south of the area investigated by the *Huxley;* nevertheless, two species, *Spongicola Koehleri* and *Uroptychus Bouvieri*, which were first described from material obtained by the *Caudan*, have again been found. Until now, both these forms were known only from the type specimens.

My thanks are due to Dr. E. J. Allen for the opportunity of examining this interesting collection.

DECAPODA NATANTIA.

PENÆIDEA.

Sergestidæ.

Sergestes arcticus, Kröyer.

Station VIII. Surface. Many, 9–22 mm.*
„ X. Surface. One, very small.
„ XII. 246 fathoms. Five, 29–35 mm.

The majority of the specimens only measure from 9 to 15 mm. in length, and the largest (35 mm.) is not half grown. The examples from St. XII were probably caught in midwater during the ascent of the net.

STENOPIDEA.

Stenopidæ.

Spongicola † Koehleri, Caullery.

Station XIII. 412 fathoms. Twenty-three, 25–46 mm., and several very young, about 8 mm.

Prior to the date of the *Huxley's* cruise, this interesting species was known only from five specimens dredged in the Bay of Biscay in 770 fathoms by the *Caudan* expedition. The additional examples, while in the main confirming the accuracy of Caullery's ‡ description, show a very considerable amount of variation in the spinulation of the carapace and certain appendages. This variation is indeed so great that no specimen in the collection exhibits precisely the same armature on both sides of its body. The following notes indicate the numbers of spines and spinules observed in some of the more important positions.

The rostrum bears from 6 to 9 teeth on its dorsal aspect. Ventrally there are two ridges (for the rostrum is triangular in section), each of which is furnished with from 0 to 4 spinules. Occasionally the foremost spinule is median in position owing to the confluence of the two ridges near the apex. The rounded antero-inferior angle of the carapace bears from 1 to 4 short spines, and from 1 to 4 are situated on the lateral face of the carapace a little behind the margin. At the

* The measurements of all the Natantia mentioned in this paper were taken from the tip of the rostrum to the apex of the telson.

† Bouvier (*Mem. Mus. Comp. Zool.*, Harvard, XXVII, 3, 1909, p. 264) gives a useful table for the discrimination of the five species comprised in this genus.

‡ "Schizopodes et Décapodes de la Campagne du Caudan." *Ann. Univ. Lyon*, XXVI, 1895, p. 382.

base of the rostrum on either side there are from 0 to 3 spines, while the posterior margin of the gastric groove may be wholly unarmed or may be provided with as many as twelve spinules. There are from 2 to 5 spinules, often blunt and inconspicuous, on the outer margin of the antennal scale, and from 4 to 14 on either side of the telson. There may also be one or two stout spines on the internal margin of the merus of third pereiopod.

The eyes, as Caullery has observed, are devoid of black pigment, except for an annular band at the proximal edge of the cornea. The small and rudimentary exopod which Spence Bate has figured * at the base of the third maxillipede of *Spongicola venusta* is not found in *S. Koehleri.*

The *Huxley*, like the *Caudan*, obtained several very young specimens of this species. Those in the present collection measure about 8 mm. in length and evidently represent the earliest free-living stage, for some remain curled up as though still within the eggshell. The rostrum and all the appendages of the cephalothorax are well developed in these specimens, while the eyes are just as deficient in pigmentation as they are in the adult. The pereiopods are fully segmented, and chelæ are present on the first three pairs, those of the third pair being very noticeable owing to their large size. Conspicuous exopods are retained on the first three pairs. The pleopods are well formed, but the uropods are not yet free and the telson is slightly emarginate distally.

An ovigerous female was found to be carrying sixty-two eggs.

As in the case of the type specimens, the examples of *S. Koehleri* collected by the *Huxley* were living in the sponge *Regadrella phœnix;* as a rule a single individual was found inside each sponge.

CARIDEA.

Pasiphæidæ.

Pasiphaë sivado (Risso).

Station VIII.	Surface.	Many, 35–55 mm.
,, IX.	240 fathoms.	Eight, 59–69 mm.
,, X.	Surface.	Many, 8–26 mm.
,, XII.	246 fathoms.	Twenty-nine, 21–40 mm.
,, XIII.	412 fathoms.	Two, 40 and 58 mm.

Only once previously has this species been recorded from depths exceeding 400 fathoms: by Adensamer, from 543 fathoms in the Mediterranean.

* *Challenger* Report, 1888, Pl. XXIX, Fig. i″.

Pasiphaë princeps, Smith.

Station XII. 246 fathoms. One, 69 mm.

This solitary individual is specifically identical with a number of specimens found off the west coast of Ireland. These, although differing in certain features from the original description, have been determined as *P. princeps*, Smith, a species closely allied to *P. tarda*, Kröyer, but extending much further south.

P. princeps had not hitherto been found in as little as 246 fathoms.

PANDALIDÆ.

Pandalus leptocerus, Smith, var. **Bonnieri,** Caullery.

Station	IX.	240 fathoms.	Twenty-six, 35–ca.110 mm.
,,	XII.	246 fathoms.	Thirty-three, 25–98 mm.

Pandalus propinquus, G. O. Sars.

Station	VII.	444 fathoms.	Nineteen, 27–70 mm.
,,	IX.	240 fathoms.	Eight, 27–34 mm.
,,	XII.	246 fathoms.	Fifteen, 18–35 mm.
,,	XIII.	412 fathoms.	Thirteen, 31–ca.75 mm.

P. propinquus had not previously been recorded as far south as the Bay of Biscay.

Plesionika martia (A. Milne-Edwards).

Station	XII.	246 fathoms.	Five; one perfect, 90 mm.
(?) ,,	XIII.	412 fathoms.	One, large, in very bad condition.

The large individual from Station XIII cannot be satisfactorily determined. It appears to have been swallowed by a fish and partially digested.

Pandalina brevirostris (Rathke).

Station	IX.	240 fathoms.	Three, 21–25 mm.
,,	XII.	246 fathoms.	Thirty, 12–25 mm.

Several of the female specimens are ovigerous.

HIPPOLYTIDÆ.

Hippolyte varians, Leach.

Station II. 75 fathoms. One, 17 mm.; an ovigerous female.

Caridion Gordoni (Spence Bate).

Station	IX.	240 fathoms.	Four, 16–21 mm.
,,	XII.	246 fathoms.	Eight, 14–18·5 mm.

The rostra of these specimens bear from six to nine teeth above and from one to three below.

C. Gordoni was not previously known to the south of the British Isles, and hitherto had not been trawled in depths exceeding 200 fathoms.

PROCESSIDÆ.

Processa canaliculata, Leach.

Station II. 75 fathoms. Two, 26 and 30 mm.
,, V. 109 fathoms. Seventy-six, 21–50 mm.

Two of the specimens have abnormal eyes. The cornea on one side is well developed and of the usual size, whereas that on the other side is much smaller with, in one case, a curious swelling on the inner face of the stalk. The rostrum of the latter specimen is also unusually short, and is not furnished with its full complement of setæ.

PALÆMONIDÆ.

Periclimenes Korni? Lo Bianco.

Station XIII. 412 fathoms. Fragment.

The rostrum of this specimen is broken off at the base, and the whole of the abdomen is missing. This is particularly unfortunate, for the specimen is, as far as I am aware, the only deep-water Palæmonid which has been found in the North-East Atlantic. It appears to be most closely allied to the imperfectly described *Periclimenes* (*Anchistia*) *Korni* (Lo Bianco),* found near Capri in about 600 fathoms, but is considerably larger and differs from the Italian author's figure in the lengths of various segments of the pereiopods.

The carapace measures 7 mm. from the back of the orbit to the hinder margin of the carapace; it is therefore probable that the specimen was originally more than twice as long as the types of *P. Korni*, which were only 13–15 mm. in total length.

The rostrum is broken, but four dorsal teeth are present on the anterior third of the carapace behind the orbital notch. The dorsal carina is clear and distinct for three-quarters the length of the carapace, fading away further back. Both hepatic and antennal spines are present. The eyes are deeply pigmented and the cornea is wider than the stalk. The outer antennular flagellum is split into two rami, the inner one (which is also the thicker) being slightly longer than the fused basal part. The lamellar portion of the antennal scale is produced acutely at its inner distal angle, and reaches considerably beyond the stout spine which terminates the straight outer margin.

The first pair of pereiopods reaches beyond the apex of the antennal scale by the whole length of the propodus; the merus and

* Lo Bianco. *Mitt. Zoo. Stat. Neapel*, 1903, p. 250, tav. 7, fig. 13.

carpus are nearly equal in length, each being about one and a half times as long as the chela. The second pair is characterised by the very long but comparatively slender chela, which is twice the length of the merus. The carpus is very short, about one-third the length of the merus, and the dactylus is half the length of the palm. The dactylus is strongly curved and sharply pointed apically; it bears a prominent longitudinal carina on either side and a sharp tooth internally in the middle of its basal third. The fixed finger is carinate along its internal aspect only, and bears, in its basal third, two teeth, between which the dactylar tooth fits when the claw is closed. In the last three pairs of pereiopods the propodus is slightly longer than the merus, the carpus is three-fifths the length of the propodus, and the dactylus is very short, simple, curved, and claw-like.

CRANGONIDÆ.

Crangon Allmanni, Kinahan.

Station II.	75 fathoms.	Nine, 18–26 mm.
,, V.	109 fathoms.	Many, 14–25 mm.
,, XI.	146 fathoms.	Many, 12–27 mm.

The capture of this species on the north side of the Bay of Biscay in 146 fathoms establishes new records both for its horizontal and bathymetric distribution. *C. Allmanni* had not hitherto been found south of the British Isles, and was not previously known from depths exceeding 100 fathoms.

The small size of the specimens seems to indicate that the species is unable to attain its maximum development in deep water.

Philocheras* echinulatus, M. Sars.

Station IX.	240 fathoms.	Forty-eight, 14–34 mm.
,, XII.	246 fathoms.	Many, 14–35 mm.

This species was not previously known as far south as the Bay of Biscay.

Philocheras bispinosus, Hailstone, var. **neglectus,** G. O. Sars.

Station II. 75 fathoms. Two, 11·5 mm.

These two specimens show no trace of the brown pigment which is sometimes such a prominent feature of the var. *neglectus* when living. The surface of the carapace and abdomen is, however, without trace of tubercles, and is pitted with microscopic punctuations exactly as in the forms with transverse brown bands.

* *Philocheras*, Stebbing, *nom. nov. vice Cheraphilus.*

P. bispinosus var. *neglectus* had not hitherto been recorded from as far south as the Bay of Biscay nor from as much as 75 fathoms. The typical form is, however, known to extend to the Azores and has been found off the west coast of Ireland in as much as 200 fathoms.

Ægeon Lacazei (Gourret).

Station IX. 240 fathoms. Fourteen, 19·5–28 mm.
,, XII. 246 fathoms. Eight, 20–25 mm.

This scarce species is closely allied to the common Mediterranean form *A. cataphractus*. It was originally described by Gourret from specimens found in the vicinity of Marseilles, and since then twelve examples have been trawled off the west coast of Ireland between 160 and 374 fathoms.

Pontophilus spinosus (Leach).

Station IX. 240 fathoms. Seven, 28–38 mm.
,, XII. 246 fathoms. Three, 9–12 mm.

Pontophilus norvegicus, M. Sars.

Station XII. 246 fathoms. Three, 13–17 mm.

DECAPODA REPTANTIA.

ERYONIDEA.

ERYONIDÆ.

Polycheles typhlops, Heller.

Station XII. 246 fathoms. Two, 29 mm.

SCYLLARIDEA.

PALINURIDÆ.

"*Phyllosoma*" (larva).

Station VIII. Surface. Two.

GALATHEIDEA.

UROPTYCHIDÆ.

Uroptychus rubrovittatus (A. Milne-Edwards).

Station VII. 444 fathoms. Four, 15–30 mm.*
,, XII. 412 fathoms. One, 19 mm.

* The measurements of all the Galatheidea mentioned in this paper were taken from the apex of the rostrum to the extremity of the telson, with the abdomen stretched out in macrurous fashion.

Uroptychus nitidus var. **concolor** (A. Milne-Edwards).

Station XIII. 412 fathoms. One, 30 mm.

Uroptychus Bouvieri, Caullery.

Station XIII. 412 fathoms. Three, 14·5–22 mm.

This is the first time this species has been recorded since it was described by Caullery.* The type specimens, two males, were found by the *Caudan* expedition between 218 and 273 fathoms.

Two of the examples collected by the *Huxley* are ovigerous females, and measure 22 and 20·5 mm. from the tip of the rostrum to the apex of the telson; the third is a male, 14·5 mm. in length. The first pereiopods measure 26, 24, and 23·5 mm. respectively, thus showing that this limb is much more strongly developed in the male than in the female.

Little can be added to Caullery's careful description. The small median denticle behind the base of the rostrum is absent in all the specimens, the lateral spines on the carapace vary in number from five to six, and the antennal scale reaches to two-thirds the length of the rostrum, and is narrower at its base than in the figure of the type. The notch in the sternal plaston is, in the female, rectangular in shape, and considerably deeper than in the male.

Only four longitudinal rows of spines can be found on the merus and carpus of the first pereiopod, and the internal edge of the propodus of the same limb is upturned and denticulate proximally and is separated from the smooth dorsal surface by a well-defined groove.

The eggs, which appear to be on the point of hatching, measure about 1·5 mm in length.

Gastroptychus formosus (A. M.-Edw. and Bouvier).

Station VII. $\overline{\dot{4}44}$ fathoms. One, 18 mm.
,, XIII. 412 fathoms. Two, 21 and 38 mm.

One of the specimens from Station XIII is an ovigerous female.

GALATHEIDÆ.

Galathodes tridentatus (Esmark).

Station VII. $\overline{\dot{4}44}$ fathoms. Twenty-four, 6·5–28 mm.
,, XIII. 412 fathoms. Four, 18–20 mm.

Nine females are ovigerous.

* "Schizopodes et Décapodes de la Campagne du Caudan," *Ann. Univ. Lyon*, XXVI, 1895, p. 394.

Galathea nexa, Embleton.

Station	II.	75 fathoms.	Two, 16 and 23 mm.
,,	V.	109 fathoms.	One small; broken.
,,	XI.	146 fathoms.	Six, 10–21 mm.
,,	XII.	246 fathoms.	Two, 15 and 18 mm.

Compared with Bonnier's figures the third maxillipede in these specimens bears a closer resemblance to *G. dispersa* than to *G. nexa*. Recent authors are, however, agreed that these two forms are merely variations of a single species, and although the form known as *dispersa* is far the commoner, yet this name must lapse in favour of *nexa*, which has priority.*

Munida bamffica (Pennant).

Station	IX.	240 fathoms.	Two, 24 and 33 mm.
,,	XII.	246 fathoms.	Four, 25–33 mm.
,,	XIII.	412 fathoms.	One, 23 mm.

Although the specimens are small, they all present the scaly appearance on the thoracic sternum which so readily separates this species from its close ally *Munida tenuimana*.*

PAGURIDEA.

Paguridæ.

Eupagurus bernhardus (Linn.).

Station II. 75 fathoms. One, very small.

Eupagurus Prideauxi (Leach).

Station	II.	75 fathoms.	Five.
,,	V.	109 fathoms.	Four.
,,	VI.	87 fathoms.	One.

In the largest specimen, which is an ovigerous female from Station VI, the carapace measures 15 mm. in length.

Eupagurus variabilis, A. M.-Edw. and Bouvier.

Station	IX.	240 fathoms.	Twenty-six.
,,	XI.	146 fathoms.	Sixteen.
,,	XII.	246 fathoms.	Twelve.
,,	XIII.	412 fathoms.	One.

The largest example, taken at Station IX, measures 62 mm. from the hinder margin of the cephalothorax to the distal extremity of the large chela. All the specimens are typical in form with the exception of two, in which the propodus of the right chela is slightly excavate.

* v. Hansen, *Danish Ingolf Malacostraca*, 1908, pp. 31 and 32.

Eupagurus carneus, Pocock.

Station VII. 444 fathoms. One.
,, XIII. 412 fathoms. Two.

The largest specimen measures only 28 mm. from the hinder margin of the cephalothorax to the distal extremity of the large chela.

Anapagurus lævis (W. Thompson).

Station II.	75 fathoms.	Seven.
,, V.	109 fathoms.	Twenty-two.
,, IX.	240 fathoms.	Two.
,, XI.	146 fathoms.	Six.
,, XII.	246 fathoms.	Four.

OXYSTOMATA.

Dorippidæ.

Cymonomus granulatus (Norman).

Station XII. 246 fathoms. One, 4 mm.*

Leucosiidæ.

Ebalia tuberosa (Pennant).

Station V. 109 fathoms. One, 12·5 mm.

This species does not seem to have been recorded hitherto from as much as 109 fathoms.

Ebalia tumefacta (Montagu).

Station II.	75 fathoms.	One, 7 mm.
,, V.	109 fathoms.	Two, 8 and 8·5 mm.

Ebalia nux, Norman.

Station V.	109 fathoms.	One, 7·5 mm.
,, IX.	240 fathoms.	Eight, 6·5–8·5 mm.
,, XI.	146 fathoms.	Three, 7–7·5 mm.
,, XII.	412 fathoms.	7–8 mm.

Several of the specimens are ovigerous females.

BRACHYGNATHA.

Portunidæ.

Portunus holsatus, Fabricius.

Station II.	75 fathoms.	Eighteen, 10·5–18 mm.
,, V.	109 fathoms.	Three, 6·5–8·5 mm.

* Length of carapace.

The specimens are all very young, but in my opinion they can be referred with safety to this species. Hitherto *P. holsatus* has not been recorded from depths exceeding 70 fathoms.

Portunus pusillus, Leach.

Station V. 109 fathoms. Eighteen, 5–9 mm.

It is with some doubt that these small specimens are referred to *P. pusillus.* The median frontal tooth is, in several instances, not more advanced than the lateral, but it is probable that with growth this feature would become more apparent.

Portunus tuberculatus, Roux.

Station III.	75 fathoms.	Two, 27 and 29 mm.
,, V.	109 fathoms.	Three, 17–21 mm.
,, VI.	87 fathoms.	Three, 21–22 mm.

Polybius Henslowi, Leach.

Station II. 75 fathoms. One, 36 mm.

Bathynectes superba (Costa).

Station VII.	444 fathoms.	Two; one 11 mm., one broken.
,, IX.	240 fathoms.	Seven, about 5·5 mm.
,, XII.	246 fathoms.	Fifty-three; one large and very macerated, the rest 5–6 mm.
,, XIII.	412 fathoms.	Four.

In the small specimens the form of the carapace resembles Bouvier's figure * of an individual 4·5 mm. in length; the frontal margin is four-lobed, the second and fourth antero-lateral spines are extremely short, while the fifth is not specially longer than the third. In the two large specimens from Station XIII the hindmost spines of the antero-lateral series are very long; they measure 50 and 46 mm. in breadth without these spines, while, including them, they measure 84 and 80 mm.

Geryon sp.?

Station XII. 246 fathoms. One, broken, 5 mm.

Atelecyclidæ.

Atelecyclus septemdentatus (Montagu).

Station II. 75 fathoms. Two, 15 and 17 mm.

* Bouvier, *Rés. Camp. Sci. Monaco*, XIII, 1899, Pl. II, fig. 1.

Maiidæ.

Inachus dorsettensis (Pennant).

Station	V.	109 fathoms.	Four, 13–18 mm.
,,	VI.	87 fathoms.	Two, 19 and 20 mm.

Inachus leptochirus, Leach.

Station	II.	75 fathoms.	Sixteen, 12–22 mm.
,,	VI.	87 fathoms.	Five, 18–22 mm.
,,	XI.	146 fathoms.	Two, 9 and 12·5 mm.

Stenorhynchus longirostris (Fabricius).

Station	II.	75 fathoms.	Twelve, 10–20 mm.
,,	V.	109 fathoms.	Two, 9·5 and 17·5 mm.
,,	IX.	240 fathoms.	One, 22 mm.

Lispognathus Thomsoni (Norman).

Station	VII.	444 fathoms.	One, 7 mm.
,,	XIII.	412 fathoms.	Four, 4–7 mm.

Ergasticus Clouei, A. Milne-Edwards.

Station	V.	109 fathoms.	One, 8 mm.
,,	IX.	240 fathoms.	One, 11 mm.
,,	XII.	246 fathoms.	Four, 9–18 mm.

Hyas coarctatus, Leach.

Station	VI.	87 fathoms.	One, 26 mm.

LIST OF SPECIES, AND THE STATIONS AT WHICH THEY OCCURRED.

STATION No.	II	III	V	VI	VII	VIII	IX	X	XI	XII	XIII
Latitude, N.	48° 24′	48° 24′	47° 48′	47° 46′	47° 36′	47° 30′	48° 7′	48° 7′	48° 10′	48° 7′	48° 7′
Longitude, W.	6° 28′	6° 33′	7° 46′	7° 12′	7° 31′	7° 31′	8° 13′	8° 13′	8° 11′	8° 13′	8° 13′
Fathoms	75	75	100	87	444	Surface.	240	Surface.	146	246	412
Natantia.											
Sergestes arcticus	...	...	...	...	...	many	...	1	...	5	
Spongicola Koehleri	...	...	...	...	...	...	...	...	...	...	23
Pasiphaë sivado	...	...	...	...	...	many	8	many	...	29	2
Pasiphaë princeps	...	...	...	...	...	...	...	...	...	1	
Pandalus leptocerus v. Bonnieri	...	...	...	...	...	...	26	...	...	33	
Pandalus propinquus	...	...	...	...	19	...	8	...	...	15	13
Plesionika martia	...	...	...	...	...	...	...	...	...	5	?
Pandalina brevirostris	...	...	...	...	...	...	3	...	...	30	
Hippolyte varians	1										
Caridion Gordoni	...	...	...	...	...	...	4	...	...	8	
Processa canaliculata	2	...	76								
Periclimenes Korni ?	...	...	...	...	..	...	...	...	...	...	1
Crangon Allmanni	9	...	many	...	...	...	...	...	many	...	...
Philocheras echinulatus	...	...	...	...	...	...	48	...	...	many	
Philocheras bispinosus v. neglectus	2										
Ægeon Lacazei	...	...	...	...	...	...	14	...	...	8	
Pontophilus spinosus	...	...	...	...	...	...	7	...	...	3	
Pontophilus norvegicus	...	...	..	...	...	...	...	...	...	3	
Reptantia.											
Polycheles typhlops	...	...	...	...	...	...	...	...	...	2	
'*Phyllosoma*' *larva*	...	...	...	...	...	2					
Uroptychus rubrovittatus	...	...	...	...	4	...	...	...	...	...	1
Uroptychus nitidus v. concolor	...	...	...	...	...	...	...	...	...	...	1
Uroptychus Bouvieri	...	...	...	...	...	...	...	...	...	...	3
Gastroptychus formosus	...	...	...	...	1	...	...	...	...	...	2

LIST OF SPECIES, AND THE STATIONS AT WHICH THEY OCCURRED—*continued.*

Station No.	II	III	V	VI	VII	VIII	IX	X	XI	XII	XIII
Latitude, N. Longitude, W.	48° 24′ 6° 28′	48° 24′ 6° 33′	47° 48′ 7° 46′	47° 46′ 7° 12′	47° 36′ 7° 31′	47° 30′ 7° 31′	48° 7′ 8° 13′	48° 7′ 8° 13′	48° 10′ 8° 11′	48° 7′ 8° 13′	48° 7′ 8° 13′
Fathoms	75	75	109	87	444	Surface.	240	Surface.	146	246	412
Galathodes tridentatus	...	...	...	...	24	...	...	...	...	...	4
Galathea nexa	2	...	1	...	...	...	...	...	6	2	
Munida bamffica	...	...	...	...	...	...	2	...	...	4	1
Eupagurus bernhardus	1										
Eupagurus Prideauxi	5	...	4	1							
Eupagurus variabilis	...	...	...	...	...	...	26	...	16	12	1
Eupagurus carneus	...	...	...	...	1	...	...	...	...	...	2
Anapagurus laevis	7	...	22	...	...	...	2	...	6	4	
Cymonomus granulatus	...	...	...	...	...	...	...	...	...	1	
Ebalia tuberosa	...	...	1								
Ebalia tumefacta	1	...	2								
Ebalia nux	...	...	1	...	...	...	8	...	3	3	
Portunus holsatus	18	...	3								
Portunus pusillus	...	...	18								
Portunus tuberculatus	...	2	3	3							
Polybius Henslowi	1										
Bathynectes superba	...	...	...	...	2	...	7	...	...	53	4
Geryon sp.	...	...	...	...	...	...	...	...	...	1	
Atelecyclus septemdentatus	2										
Inachus dorsettensis	...	...	4	2							
Inachus leptochirus	16	...	...	5	...	...	...	...	2		
Stenorhynchus longirostris	12	...	2	...	...	...	1				
Lispognathus Thomsoni	...	...	...	...	1	...	...	...	...	...	4
Ergasticus Clouei	...	...	1	...	...	...	1	...	...	4	
Hyas coarctatus	...	...	...	1							

On the Artificial Culture of Marine Plankton Organisms.

By

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and

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Introduction. The observations to be recorded in this Paper were commenced in March, 1905. They originated in an attempt to find a general method for rearing marine larval forms. Several investigators had previously succeeded in rearing Echinoderms, Molluscs, and Polychætes from artificially fertilized eggs under laboratory conditions, but the process was generally difficult and the results more or less uncertain. The most promising method seemed to be that adopted by Caswell Grave (26), who was able to rear his larvæ by feeding them on diatoms. Grave obtained his diatoms by placing sand, collected from the sea bottom, in aquaria and using such diatoms as developed from this material. All the methods, however, suffered from the uncertainty of not knowing what organisms were introduced into the aquaria in which the larvæ were to be reared, either in the original sea-water or along with the food-supply.

It appeared, therefore, at an early stage of the work, worth while to make an attempt to carry out rearing experiments on a more definite and precise plan, to endeavour, in fact, to introduce the larvæ to be reared into sterile sea-water, and to feed them with pure cultures of a suitable food. This was the ideal to be aimed at. As a matter of fact, it has seldom, if ever, been attained in practice; nevertheless a considerable measure of success has been achieved by working upon these lines, and during the course of the work innumerable problems relating to the physical conditions under which plankton organisms can best flourish have presented themselves. Some account of the experiments made may be of interest to other workers, although many of the problems raised are not yet solved, notwithstanding the fact that some 1500 cultural experiments have been under observation. It is rather with a view of stimulating other work upon similar lines, than of bringing forward conclusive results, that this paper is being published.

In the summer of 1907, Mr. E. W. Nelson became associated with the investigation, and since that date the experimental work has been carried out by him. The discussions in this paper of a more chemical character, particularly the section on alkalinity, are almost entirely the work of Mr. Nelson, and we have both had throughout the advantage of the constant advice and help of Mr. D. J. Matthews on all such matters.

I. CULTURE OF PLANKTON DIATOMS.

A. Practical Culture Methods.

1. *Miquel's Method.* Attention was first directed to the culture of Plankton diatoms; and the methods, which had been elaborated by Miquel (11) for fresh-water diatoms and had been found by him to succeed with marine-bottom diatoms, were tried.

The essential features of Miquel's method, as applied to marine diatoms, are as follows:—

Two solutions are prepared:—

Solution A.

Magnesium sulphate	10 grm.
Sodium chloride	10 ,,
Sodium sulphate	5 ,,
Ammonium nitrate	1 ,,
Potassium nitrate	2 ,,
Sodium nitrate	2 ,,
Potassium bromide	0·2 ,,
Potassium iodide	0·1 ,,
Water	100 ,,

Solution B.*

Sodium phosphate	4 grm.
Calcium chloride (dry)	4 ,,
Hydrochloric acid	† 2 cc.
Ferric chloride	‡ 2 ,,
Water	80 ,,

Forty drops of Solution A and 10 to 20 drops of Solution B are added to each 1000 cc. of sea-water, and the sea-water is sterilized by keeping it at 70° C. for about 20 minutes.

According to Miquel it is also necessary to add "organic nutritive material in the form of bran, straw, or filaments of weed such as Zostera. Macerations of these should be made up separately, some time before they are required for use, and should be carefully filtered and sterilized. Organic matter must, however, be used very sparingly,

* "The preparation of Solution A presents no difficulty; Solution B should be made up as follows: To the Sodium phosphate dissolved in 40 cc. of water are added first the 2 cc. of Hydrochloric acid, then the 2 cc. of hydrous Ferric chloride and then the 4 grm. of Calcium chloride dissolved in 40 cc. of water, taking care to shake the mixture, which I call Phospho-ferro-calcic solution. The addition of this last solution to the maceration throws down a slight brownish flocculent precipitate, formed for the most part of Ferric oxide, which should be carefully separated from the liquid used for cultivations."

† "Acid chlorhydrique pur à 22°." Presumably meaning degrees Baumé = sp. gr. 1·169.

‡ "Perchlorure de fer liquide à 45°." As above = sp. gr. 1·421.

or else putrefaction will set in and the cultures will be irrevocably lost." As a matter of fact, we have found that such organic infusions are unnecessary, when dealing with plankton diatoms, and it has not been our practice to employ them (cf., however, p. 445).

Miquel obtained cultures of single species of diatoms either by picking out individual diatoms under the microscope and introducing them into the prepared water, or by adding a small quantity of water containing a mixture of diatoms and other organisms to some prepared water, and subdividing this into a number of tubes. If the subdivision has been carried out sufficiently some of the tubes may contain one kind of diatom only, from which fresh cultures can be made. In this way, by repeated subdivision, cultures can be obtained which, by inoculating fresh quantities of prepared water from time to time, may, with care, be maintained indefinitely. Such cultures, however, must practically always contain bacteria, and Miquel distinguishes them from bacteria-free cultures, which he terms "Cultures des Diatomées a l'état de pureté absolue." The latter he found very difficult to obtain, but, through repeated washing in sterile water, followed by fractional subdivision, he succeeded in getting some in which he could find no trace of bacteria by ordinary bacteriological methods (cf. Miquel 11, p. 155; cf. also Richter, 16–18).

We propose to call any diatom culture, which can be carried on practically indefinitely by inoculating fresh supplies of prepared water, a "*persistent*" culture, the term "*pure*" culture being reserved for cultures which can be proved to contain not more than one organism. We are not satisfied that we have yet succeeded in obtaining cultures of the latter kind. For the most part our persistent cultures contain one species of diatom only, and are free from all organisms larger than small flagellates.

In our earlier experiments with plankton diatoms, we obtained persistent cultures, containing a single species of diatom, by both of the methods recommended by Miquel. We, however, have rarely succeeded by picking out single diatoms or chains of diatoms, for although we have passed the selected diatom through several changes of sterilized sea-water, the resulting cultures, even when the diatoms have multiplied to some extent, have generally shown evidence of contamination by harmful organisms, and have soon died down. Only in one of the earliest experiments, and in one more recent, has complete success resulted. In the first case a small chain of six or eight frustules of *Skeletonema costatum*, picked out in April, 1905, gave rise to a culture which still persists (Nov., 1909). Subcultures can still be obtained even from the original flask inoculated in April, 1905. In the

second case a chain of 8 or 9 cells of *Chaetoceras densum*, picked out from a Petri dish culture, has given a particularly good growth.

The method of dilution and subdivision has been more successful and persistent cultures of a number of species have been obtained in this way.

A more ready method of obtaining the cultures is, we have found, to add one or two drops of plankton to, say, 250 cc. of a suitable sterile culture medium, and to pour this into shallow glass dishes (Petri dishes). The dishes should be placed in a position as free as possible from vibration, and where they can be easily examined with a lens *in situ*. The temperature should be kept as constant as possible and the dishes exposed to light of moderate intensity, direct sunlight being avoided. In the course of a few days, colonies of diatoms of different species will be seen at different spots on the bottom of the Petri dishes. These can be picked out with a fine pipette and transferred to flasks containing fresh culture medium. The colonies should be picked out from the Petri dishes at as early a stage as possible, because if left too long some one organism, a diatom or a flagellate, may have multiplied so rapidly that the whole of the water in the dish becomes infected with it. In this case persistent cultures of a single species would not be obtained. The above method is similar to one described by Miquel, excepting that he placed gelatinous silica at the bottom of the vessel. Some very successful persistent cultures were obtained from the following experiment, which will serve to illustrate the method:—A sample of plankton, from a very fine-mesh bolting-silk tow-net, was diluted down with sterile sea-water, until a single drop examined under a two-thirds-inch objective contained on an average ten organisms, chiefly diatoms of various species. Petri dishes (4 in.), containing 60 cc. each of Miquel sea-water, were then inoculated with various numbers of drops of the diluted plankton. The two dishes, to which two and three drops respectively were added, gave the best results; and from these persistent cultures of several species of diatoms were obtained Hence we may conclude that the most advantageous number of single cells or short chains of cells to be added to a 4 in. Petri dish, containing 60 cc. culture medium, is about 20 to 30.

We have succeeded in obtaining the following species of Plankton diatoms in persistent cultures:—

Asterionella japonica, Cleve.
Biddulphia mobiliensis (Bail.), Grun.
Biddulphia regia (M. Schultze).*

* See pp. 461.

Chætoceras densum, Cleve.
Chætoceras decipiens, Cleve.
Chætoceras constrictum, Gran.
Cocconeis scutellum, Ehr. var. *minutissima*, Grun.
Coscinodiscus excentricus, Ehr.*
Coscinodiscus Granii, Gough.
Ditylium Brightwellii (West), Grun.
Lauderia borealis, Gran.
Nitzschia closterium, W. Sm.
Nitzschia closterium, W. Sm., *forma minutissima.*
Nitzschia seriata, Cleve.
Rhizosolenia stolterfothii, H. Perag.
Skeletonema costatum (Grev.)
Streptotheca thamensis, Shrubs.
Thalassiosira decipiens, Grun.*

It is hardly necessary to add that in dealing with these cultures, similar precautions to those used in bacteriological work must be taken, all vessels and instruments being carefully sterilized before they are brought into contact with the prepared sea-water. The cultures are best made in small, wide-mouthed flasks, which may be plugged with cotton wool, or simply covered with watch-glasses. The flasks should be kept at as uniform a temperature as possible (from 12°–17° C.) and should be exposed to strong daylight, direct sunlight being avoided. A flask should not be more than half filled with culture fluid, so that the surface exposed to the air may be large in proportion to the volume of fluid.

Other Methods. The addition of the solutions devised by Miquel to sea-water has in all cases given us good cultures of diatoms, and the method is certain in its action. We have, however, made numerous experiments by treating sea-water in other ways, with a view to finding out what are the best conditions under which plankton diatoms will grow, and of arriving at some explanation of the action of the different salts contained in Miquel's solutions.

2. *Houghton Gill's Method.* H. Houghton Gill (5), a contemporary of Miquel, made use of a culture medium not essentially different from that employed by the latter. Unfortunately he died before publishing his work, but an account of his principal results is given by Van Heurck. In his final method Houghton Gill made use of four distinct solutions, as follows:—

* See p. 460.

Solution 1.

Crystallized sodium phosphate	2 grm.
Calcium chloride	4 ,,
Syrup of iron chloride	0·5 ,,
Strong hydrochloric acid	1 ,,
Water	100 ,,

Solution 2.

Crystallized magnesium sulphate	4 ,,
,, sodium sulphate	4 ,,
,, potassium nitrate	4 ,,
Common salt (sodium chloride)	8 ,,
Potassium bromide	0·2 ,,
Potassium iodide	0·2 ,,
Water	100 ,,

Solution 3.

Crystallized sodium carbonate	4 ,,
Water	100 ,,

Solution 4.

Well-washed, precipitated calcium silicate	25 ,,
Water	75 ,,

All the salts employed must be chemically pure. Three cc. of each of these liquids are added to 1000 cc. of fresh water or sea-water (according to circumstances), and the whole sterilized. In his earlier work Houghton Gill added a sterilized infusion of grass or of diatoms, but it is not clear from the accounts whether this was still employed with the above solutions. We have obtained very good cultures with the above solutions, to which we did not add any organic infusion.

3 (*a*). *Modification of Miquel's method. "Miquel Sea-water."*

Since several of the components in Miquel's formula for solution A (p. 423) are obviously unnecessary, when sea-water is being used as the basis of the culture-medium, we adopted for our own work the following modifications:—After some preliminary experiments it was found, as would be expected from the composition of sea-water, that the only salts of value to the medium are the three nitrates, KNO_3, $NaNO_3$, NH_4NO_3, and possibly KBr and KI. The omission of the two latter was soon found to make no difference. Experiments also showed that the formula for solution A could, without any appreciable detriment to results, be further simplified to the one salt, KNO_3, or $NaNO_3$, but not NH_4NO_3. At first the amount of KNO_3, dissolved in 100 cc. distilled water, used to make the modified solution A, was the same as the sum of the weights of the nitrates in

Miquel's own formula, viz. 5 grm. But later experiments showed that a considerably greater concentration of KNO_3 than this gave more lasting cultures; the strength of solution, and amount to be added to a litre of sea-water, in order to obtain the best results, being 2 cc., 2M, KNO_3.

In the case of solution B no modification has been adopted, but it has been found that small variations in the amounts of the ingredients used do not affect the results. A convenient method for measuring the right amount of $FeCl_3$ is to warm the salt until it just melts in its own water of crystallization, and to pipette out 2 cc. with a previously warmed pipette. No temperature corrections need be considered. Also 2 cc. of the ordinary pure concentrated hydrochloric acid at room temperature will suffice.

Our own formula for preparing Miquel sea-water is now:—

SOLUTION A.*

Potassium nitrate	20·2 grm.	= 2M KNO_3
Distilled water	100 ,,	

SOLUTION B.†

Sodium phosphate ($Na_2HPO_4 12H_2O$)	4 ,,
Calcium chloride ($CaCl_2 6H_2O$) . .	4 ,,
Ferric chloride (melted) . . .	2 cc.
Hydrochloric acid (pure, concentrated)	2 cc.
Distilled water	80 cc.

To each 1000 cc. of sea-water‡ add 2 cc. solution A and 1 cc. solution B, and sterilize by heating to 70° C. When cool, decant off the clear liquids from the precipitate, which will have formed when solution B is added to the sea-water.

As a rule our cultures were made in 60 cc. of this medium, contained in short-necked, wide-mouthed flasks of 125 cc. capacity, so that the proportion of air-surface to volume of liquid was large.

The medium was found to give constantly satisfactory results. On inoculation from a persistent culture of such diatoms as *Thalassiosira*, *Skeletonema*, *Chaetoceras*, etc., a growth visible to the eye is obtained in about ten days, and then multiplication takes place very rapidly. In from three weeks to a month's time a very considerable growth will be seen making a brown, flocculent mass at the bottom and back of the vessel containing the culture.

* This strength has only been used in the most recent experiments; and solution A in this paper, unless otherwise stated, means the five per cent solution of KNO_3.

† For preparing this solution see p. 423.

‡ "Miquel water" seems to succeed equally well, whether it is made by adding Miquel's solutions to "outside water" or to "tank water" (cf. p. 437).

In from three to four months the culture begins to show signs of exhaustion and the frustules lose colour, but they do not, as in the case of sterilized outside and tank water, completely die off. A great number certainly do die, but some remain in a resting condition, and often, after a period of six months or so, these begin to multiply again and the culture regains its former vigour. This is probably due to the food-stuffs contained in the dead frustules going into solution again, possibly by means of bacterial action. This periodicity in cultures is interesting in that it resembles what takes place in the ocean. Cultures in this medium will persist indefinitely, so far as our experience goes. The oldest culture in our possession is one of *Skeletonema costatum*, made at the very commencement of this work, dated April, 1905. Although the frustules in this culture are quite unrecognizable as any diatom now, on making a subculture in fresh Miquel a normal and healthy growth can always be obtained.

In old cultures the diatoms are nearly always found to be very much deformed, and often appear to be only a mass of broken-down chromatophores. Whether regeneration can be successfully obtained from a single chromatophore, which must presumably be contained within a cell-wall of some kind, has not been definitely decided, but results seem to point in this direction.

At the start of a culture a tendency to teratological forms is often exhibited, but when the growth is well advanced, the shape of the frustules is usually quite normal.

(*b*) *English Channel Water* ("Outside Water").—In a large number of our experiments sea-water brought in from outside the Plymouth breakwater, and therefore taken at some distance from the shore, has been used. This is referred to as "outside water." It has an average salinity of about 35·0 °/₀₀, and the temperature range for the year is from 8° C. to 16° C.

If a sample of "outside water" is inoculated from a persistent culture of a plankton diatom, a small growth is obtained in from five to fifteen days. But soon minute bottom forms of diatoms, other algæ, flagellates, infusoria, etc., appear, and the inoculated species is lost. The total growth of any form is never large. If the growth of these foreign forms is prevented by sterilizing the water before inoculation, a considerably better growth of the plankton form is obtained. The water was, as a rule, sterilized by simply heating to 70° C., which temperature was found to be quite adequate. Boiling gave equally good results, but the former was preferred, as less concentration due to evaporation took place. Even under these conditions

no permanent culture can be obtained, the diatoms soon beginning to lose colour and getting into an exhausted condition. Death takes place in from two to three months after the culture has been started, and in many cases considerably sooner. Long before inability to start new cultures, the test of death, has been established, the valves appear on examination quite colourless and practically empty.

Samples of outside water, taken at times when the quantity of plankton was widely different, gave no appreciable variation in the results obtained by culture methods. It is, however, doubtful whether differences in the amounts of growth in cultures, proportional to the seasonal variation in the quantity of phytoplankton, would be sufficiently marked to be appreciable.

The total growth under cultural conditions, although small for a culture, is very much greater than any natural plankton that has come within our experience.

(c) *Tank-water.*—"Tank-water" or water taken from the supply of sea-water circulating through the tanks of the Aquarium at Plymouth, shows some striking and interesting differences from "outside water." This water is pumped up from the sea, just below the Laboratory, into two large, covered-in, settling reservoirs, with a capacity of 50,000 gallons each. Pumping is only done at high water, spring tides, so as to get the least contaminated water, and no water is pumped that does not show a specific gravity, measured with a hydrometer, of $\rho^{17\cdot5} = 26\cdot00$ ($S = 34\cdot00$) or over. The water is allowed to settle for about a fortnight before being used for the general circulation.

The tanks themselves are made of slate and glass, and the pipes which convey the sea-water to them are of vulcanite, so that the water does not come in contact with metal, excepting in the pumps, which are of cast-iron. The two settling reservoirs are used alternately, for about a week each. From time to time, tide and water allowing, waste is replenished, and about twice a year each reservoir is emptied, cleaned out and refilled. The aquarium takes about 20,000 gallons, and this is in circulation with one of the two 50,000-gallon reservoirs. An estimate of the amount of life in the tanks of the aquarium must be exceedingly rough, but the intensity of the larger forms of life is far greater than anything met with in natural waters. About 500 fish and 2000 invertebrates, including all forms as large as an *Actinia equina*, might be somewhere near the mark. So it will be seen that the accumulation of excretory products must be a by no means negligible factor. The flora of the tanks is very restricted, and is chiefly composed of minute forms of algæ. Minute naviculoid diatoms,

Ectocarpus, *Cladophora*, *Enteromorpha*, *Vaucheria*, and unicellular algæ are the commonest forms. The large seaweeds, such as *Fucus* and *Laminaria*, do not live long if introduced. Plankton diatoms, although a great number must be pumped up when the reservoirs are being filled, are not represented.

As in the case of outside water, a sample of "tank-water," inoculated from a persistent culture, will only give a very small growth, minute forms, etc., soon multiplying and choking out the plankton form. The ultimate growth of minute unicellular algæ other than diatoms is often considerable, and many quite unknown and unidentified forms have been obtained. The total growth of vegetable forms is always found to be greater than in the case of outside water.

In cultures of plankton diatoms made with sterilized tank water, a very great improvement on outside sterilized water was always noted. The culture of the diatom used to inoculate this medium persists for a considerable period, and the colour of the frustules remains normal for two to three months.

(*d*) *Animal-Charcoal Water.*—The use of animal charcoal, as a means of purifying the water in small aquaria, has for a long time been known and practised by those who have kept such aquaria in inland places. At an early stage in our experiments, water from a tank, which was not in a satisfactory condition, was treated with some powdered animal charcoal and filtered. It was noticed that a good growth of diatoms took place in this water. Systematic experiments with the use of animal charcoal were then commenced, and these have resulted in a method of great value, both for the culture of diatoms and for the rearing of pelagic larvæ.

Animal charcoal is made by the carbonization of bones,* and is sold in two grades known as "pure" and "commercial." Our earlier experiments were all made with "pure" animal charcoal, but subsequently the "commercial" animal charcoal was largely used and appears to give equally good, if not better results. In both cases the animal charcoal is used in the powdered form. Animal-charcoal water is prepared as follows:—

1. A quantity of sea-water is sterilized by heating it in a flask to

* Analysis of Animal Charcoal, from Thorpe's *Dictionary of Applied Chemistry*:—

Carbon	10·51
Ca., Mg. phosphates, Ca. fluoride, etc.	80·21
Calcium carbonate	8·30
Other mineral matter	0·98
	100·00

70° C., at which temperature it should be kept for about twenty minutes. At the same time some animal charcoal is heated sufficiently to sterilize but not to burn it, covered over and allowed to cool. When both are quite cold, the charcoal is added to the water (ca. 15 grm. to 1000 cc.) and well shaken up in it several times. After an interval of half an hour or more the water is filtered through fine filter cloth,* the whole filter having been first sterilized with boiling sea-water, and is received in a sterile flask. It is then ready for use.

2. For many experiments, where larger quantities of water were required, the sea-water was not sterilized before being treated with animal charcoal. In this case, if the first part of the filtrate be rejected, the subsequent water will generally be practically sterile, and few, if any, extraneous organisms will develop in it.

3. At a later date an automatic apparatus was set up in the Plymouth Laboratory, by which very considerable quantities of sea-water could be treated with animal charcoal, and subsequently filtered through a "Berkefeld" filter; water treated in this manner we call "Berkefeld water." Tank-water was always used in this apparatus, and was mixed with animal charcoal,† in a clean sulphuric acid carboy, by blowing air through with a pair of bellows. The mixture was allowed to settle for at least twenty-four hours and then syphoned over into an inverted bell-jar, with a tubulure at the bottom, into which the Berkefeld candle was fitted. Filtration under these conditions was found to be rather slow; so, in order to increase its rate, an apparatus was devised by which the pressure on the filter was considerably augmented.

This apparatus (see Fig. 1) consists of a glazed earthenware "tobacco jar" with two tubulures, one at the side, the other at the bottom, and a lid which can be screwed down tightly on to a rubber washer, by means of a triangular metal arrangement fitting into grooves above the lid.‡ The internal dimensions of our jars are 11 × 6 inches, and the diameter of the opening at the top is 3¼ inches. The tubulures are coned, with the smaller diameter external, and make a good fit for a No. 8 rubber bung. When setting up this apparatus, a bung, through which a short glass tube bent at right angles is passed, is fitted into the

* The filter cloth used for this purpose is the same as is made for use in filter presses, and is known as Extra-Super Swansdown. To prevent this becoming clogged another cloth, known as Hydraulic Twill, was, as a rule, used over it.

† Ca. 300 grm. to 20 litres of water.

‡ These jars were made, to our specification, by Messrs. Price, Powell, and Co., Bristol. The clamps usually supplied with such jars are not strong enough to obtain a tight joint, but these are easily replaced by stronger ones.

side tubulure. This tube is connected, by means of rubber pressure tubing, to another glass tube leading down from the bottom of a small inverted bell-jar, placed some height above (in our case 14 feet, which gives a pressure of ca. 6 lbs. to the square inch inside the jar). A screw pinch-cock on this connection serves as a tap. The carboy containing the treated water stands just above the bell-jar, and is fitted with a tightly fitting rubber bung, through which two tubes pass. One is an ordinary syphon, the other the only air inlet into the carboy. This latter automatically keeps the level of the water in the bell-jar

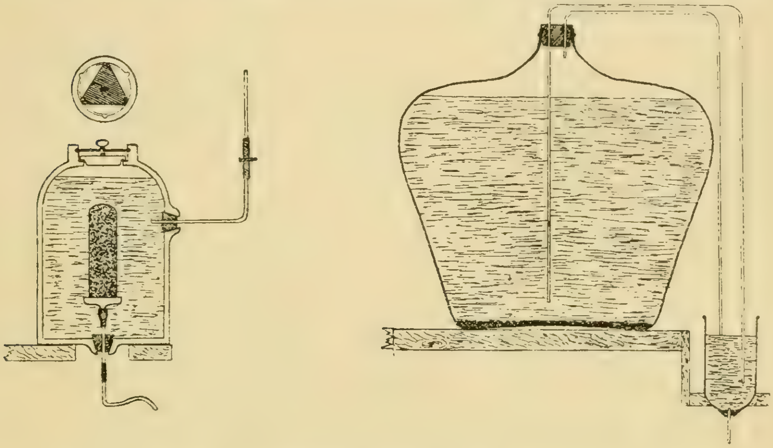

Fig. 1.—Diagram of apparatus for preparing sterile sea-water by filtration, without contact with metal.

constant, by closing the air-inlet as soon as the water covers the end of the tube. When filtering water, the *modus operandi* is as follows :—

The carboy is filled with tank-water, treated, and allowed to settle as before. The Berkefeld candle,* bung, delivery tube, and connections (see Fig. 1) are sterilized by boiling for half an hour and fitted into place from within. (The delivery tube is shaped so that any drops of water, accidentally running down outside it, do not enter the vessel receiving the filtrate ; and the jar should be large enough to allow the hand to fit the filter into place without much trouble.) The pinch-cock is closed and the syphon from the carboy started, which will automatically stop if the bung has been properly fitted. This should be watched to avoid accidents. The pinch-cock is then opened until the water rises in the jar well above the top of the candle, but still leaving some air space. The lid can now be fitted into place and screwed down. The tightness of this joint can be tested by pouring a little water into

* No. 5. Porcelain-mount ; length 8 ins., diameter 2 ins.

the crack round the lid, and observing if any bubbles are formed when the pinch-cock is opened. If all is right, no bubbles will be seen, and a good stream of water will flow out from the delivery tube. Our apparatus will filter about twenty litres an hour, and the filtrate is exceptionally bright and clear. The candle should be sterilized every three or four days that the apparatus is in use, to avoid indirect contamination by growths of organisms through the substance of the filter.* The water while passing through this apparatus only comes into contact with glass, earthenware, and rubber, the use of metal having been purposely avoided.

(*e*) *Peroxide of Hydrogen Water.* As it seemed probable that the action of animal charcoal was due to contact oxidation with the oxygen occluded in the charcoal, experiments were made to determine whether a similar effect could be produced by the use of hydrogen peroxide (H_2O_2). This was used in two ways. In the first method a sufficient quantity of H_2O_2 was added to the sea-water to ensure complete sterilization (1 cc. of H_2O_2 of 20 vols. strength per 1000 cc. of tank-water was found to be satisfactory), and the excess of H_2O_2 was decomposed by adding manganese dioxide. The water was then filtered through filter cloth, and the filtrate appeared to remain quite sterile. Good cultures of *Chaetoceras constrictum*, *Biddulphia mobiliensis*, and *Skeletonema costatum* were made in this water, which seemed to be as good as water treated by the animal-charcoal method.

The second way of using the peroxide of hydrogen was to start with water sterilized by heating to 70° C., and to add to this H_2O_2, in small quantities at a time, until its presence could just be detected on testing the sea-water with permanganate of potash. In these circumstances, the first amounts of H_2O_2 are decomposed in the oxidation of organic substances in the water, and a very slight excess of H_2O_2 persists. For tank-water 1 cc. of 1 vol. H_2O_2 per 1000 cc. was found to give the best general effect. Cultures grown in water prepared in this way developed satisfactorily, being practically equal to those made in animal-charcoal water, but they became exhausted rather quickly.

The treatment of aquarium water with ozone was also tried, as this seems to offer a possibility of treating large quantities of water,† such as the whole bulk of water in an aquarium circulation, without very considerable expense. Experiments on a small scale, which we were able to make, unfortunately only with imperfect apparatus, showed

* See Bulloch and Craw., *Jour. of Hygiene*, VI, No. 3 (1906) p. 409.

† The use of ozonized air for the purification of fresh water for town-water supplies has been adopted in some localities. See Bridge, J. H. Paper read before Franklin Institute, reprinted in *English Mechanic* (1907), pp. 369 and 392.

that water treated with ozonized oxygen gave distinctly better cultures than untreated water. Although the sea-water was not absolutely sterilized by the treatment to which we actually subjected it, a sample of water which was visibly clouded with bacteria became quite clear and bright.

(*f*) *Cultures in these Media.* In order to make clear the different results, which are obtained by using these different waters, we will describe the probable result which would be got from a series of flasks set up with the following media, and each inoculated with a persistent culture of a true plankton diatom, such as *Thalassiosira*, *Skeletonema*, or *Chaetoceras.*

A. "Outside water" untreated.
Small growth in from five to fifteen days, almost immediately swamped by growths of foreign forms; the latter, however, will never be large.

B. "Outside water" sterilized.
Slightly larger growth, very soon becoming exhausted.

C. "Tank-water" untreated.
Same result as in A, but growths will be much larger, healthier, and will last longer.

D. "Tank-water" sterilized.
A fair growth of the inoculated species, but the total growth will not be as great as in C; the diatoms will retain their normal appearance for some time.

E. "Outside water" + Miquel's solutions A and B, sterilized.
Best culture in series, both in quantity and quality. The diatoms will remain normal and healthy for a very long period.

F. "Outside water" sterilized and treated with Animal Charcoal.
Fair growth, especially at first; diatoms will soon grow pale and become exhausted; better than D.

G. "Tank-water" sterilized and treated with Animal Charcoal.
As F, only growth will be slightly greater and will last considerably longer. Third best in series.

H. "Tank-water" treated with Animal Charcoal and filtered through Berkefeld filter.
This will usually be the second-best culture in the series, but the difference between this and G will only be slight.

K. "Outside water" treated with H_2O_2.
This will most resemble F, but will not be quite so good.

L. "Tank-water" treated with H_2O_2.
A distinct improvement over K. This medium is rather variable, and in some cases the growth obtained has been quite equal to F, if not better.

B. Experiments with a View to Determining the Conditions which underlie the successful Culture of Diatoms.

The attempt to make cultures of diatoms for use as food, when rearing pelagic larvæ, led naturally to an effort to determine the best culture medium and the most favourable conditions for the rapid and continuous growth of diatoms. Before success can be attained in this direction exact knowledge as to the nature of the essential food-stuffs—and in fact as to the general physiology of the Diatomaceæ—is necessary.* Numerous experiments, extending over the last three years, have been carried out, with a view to obtaining such knowledge, and the results, though still by no means complete or conclusive, are perhaps worth recording.

A great difficulty which has to be met in carrying out such investigations on marine diatoms is caused by the fact that, when sea-water is used as a basis for the culture media, we are dealing with a solution of a very complex and very variable character, the exact nature of which it is extremely difficult to determine. The most direct method of research, namely, chemical analysis, has not proved of much service, owing to the uncertainty and in many cases impossibility of accurate determinations, in sea-water, of such minute quantities of substances as those upon which the growth of plankton diatoms has been found to depend.

We have had, therefore, to rely, for the most part, on the lengthy and tedious process of analysis by "trial and error," the experiments being largely conducted on lines suggested by Liebig's well-known "law of minimums" (Pfeffer, vol. i., p. 413). The ideal at which we aim is to find a culture medium, with artificially prepared sea-water as its basis, such that the absence, or diminution in quantity, of any one of its constituents would have a profound effect upon the growth of diatoms in it. Whether the conditions regulating growth in such a medium would be at all comparable to the natural conditions of life in the sea is a question that would have to be decided by experiment, but in any case this could be made a starting point for much more definite research than has yet been attempted. Up to the present time we have not, unfortunately, succeeded in finding such a culture medium. Throughout the work we have had very great difficulty, in spite of much care and many precautions, in obtaining consistent results. It may even happen that, in two flasks containing the same culture medium, inoculated with the same culture of diatom and standing side

* For general references to literature see Bibliography, especially Miquel (12), Richter (18).

by side, under exactly identical conditions, as far as can be recognized, quite different degrees of growth will be observed. All experiments must therefore be frequently repeated before entire confidence can be felt in any conclusions which they seem to indicate.

It must be remembered, also, that in all the persistent cultures of diatoms that we have used, bacteria have probably been present, and this fact has probably had some influence on the result. Unfortunately our attempts to obtain absolutely pure cultures have not met with success.

Methods. In carrying out the experiments to be described in this section the procedure has been as follows:—All media have been prepared from sterile sea-water, and sterile vessels and instruments have always been used. The cultures have usually been made in 60 cc. of liquid, in short-necked, wide-mouthed flasks of 125 cc. capacity. When a number of cultures were to be compared, the flasks were kept standing in a row together in such a way as to keep the physical conditions as similar as possible. Control cultures in standard media were included in each series, so that results from different series could be compared by reference to the controls. The various media were inoculated from a persistent culture of a species of plankton diatom, which in the great majority of cases was *Thalassiosira decipiens* (p. 460). When preparing the different media the methods used were, as far as possible, identical, and although only about 60 cc. was needed for a culture, a litre was made up, so that errors due to measuring very minute quantities might be avoided. The media were all freshly prepared for each comparative series of cultures, the same sample of sea-water being used, when the basis of any two or more was the same. Comparative estimates of the amount of growth in the different cultures were made by eye alone. Any difference between amounts of growth that has been described here as appreciable has always been accompanied by a marked difference in appearance to the eye on holding the cultures up to the light. A few drops from each culture were also, from time to time, examined microscopically as a test of the quality and purity of the growth.

The sea-water employed. The sea-water employed as a basis for the culture media has been either (1) "outside water" or (2) "tank-water." A general description of these will be found on pp. 429–431. An accurate chemical analysis of both types of water would probably make clear many difficult points, but, as already pointed out, no chemical methods of sufficient delicacy have yet been devised.

We have seen that if we compare "tank-water," i.e. water from the closed circulation of the Plymouth Aquarium, with off-shore sea-water *in situ*, a most obvious difference is the much increased density of the larger forms of animal life in the former, combined with the almost complete absence of plant life. Hence the concentration of excretory products in the tank-water must be very much higher than in outside water. Other factors, such as increased bacterial action, artificial aeration, etc., in tank-water, must also be taken into account (cf. Vernon, 58; Smith, 56). There seems to be direct evidence to show that the concentration of nitrates, possibly due to the action of nitrifying bacteria on the products of excretion, such as urea, ammonia, etc., is considerably higher in the tank-water, and the presence of soluble organic matter, in concentrations never met with in the sea, can almost certainly be assumed. It is probably due to the presence of these nitrates and soluble organic substances that sterilized tank-water is a much better medium in which to grow diatoms than sterilized outside water (see p. 435).

The constituents of Miquel's solutions. It has already been stated that no better medium for the culture of plankton diatoms has been found by us than the solutions recommended by Miquel, although these solutions may be modified and simplified in various ways with equally good results. The formulæ recommended by Houghton Gill give very similar cultures. The essential features of Miquel's and Houghton Gill's methods, when adapted to sea-water, are the same. Miquel's solution A, and Gill's solution 2, can both be replaced by a solution of potassium nitrate (p. 427). Again, Miquel's solution B and Gill's solution 1 only differ in the proportionate amounts in which the various constituents are prescribed. The formulæ are:—

	Miquel's sol. B.	*H. Gill's sol.* 1.
$Na_2HPO_4, 12H_2O$	4 grm.	2 grm.
$Ca\,Cl_2$	4 ,,	4 ,,
$Fe\,Cl_3$ (syrupus)	2 cc.	0·5 ,,
HCl (concentrated)	2 cc.	1 ,,
Water	80 cc.	100 ,,
	Use 1 cc. per 1000.	Use 3 cc. per 1000.

The proportionate amounts added to equal volumes of sea-water are:—

	Miquel's sol. B.	*H. Gill's sol.* 1.
Na_2HPO_4	10	12
$Ca\,Cl_2$	10	24
$Fe\,Cl_3$	5	3
HCl	5	6

Since cultures can be obtained with no appreciable difference by using media prepared by adding either of these solutions, together with Miquel's solution A, to sea-water, a considerable latitude in the proportions of the salts present is tolerated.

We must now consider what is the *rôle* of the various constituents in Miquel sea-water. The part played by any salt of a culture medium may be considered as being either, firstly, "nutritive," or secondly, "protective."* Under the first heading, any direct addition of food material must be included; under the second, any removal or neutralization of harmful substances, such as toxins and possibly bacteria, and any more remote effects, which, although influencing growth, do not directly enter into the metabolism of the plant.

Our experiments have proved that solution A can be reduced to a simple solution of potassium nitrate† without detriment (cf. p. 427), and that the amount of growth is, within limits, roughly proportional to the amount of KNO_3 added, as the following experiment shows:—

Inoculated from persistent culture of *Thalassiosira decipiens.*

A. Normal Miquel sea-water.
    Growth as usual.

B. Ditto, but only one-half amount of sol. A.
    Good growth at first, but exhausted sooner than A.

C. Ditto, but $2\frac{1}{2}$ times amount of sol. A.
    Was slower than either A or B at start, but afterwards was better than A or B and lasted longer.

D. Ditto, but five times amount of sol. A.
    As C, but in greater degree.

Considering the nature of the substance added, and its already well-known action in plant metabolism, these results, coupled with the fact that exhausted cultures can often be regenerated by the simple addition of nitrates (see below, p. 444), are quite consistent with the assumption that sol. A is simply nutritive in action. The concentration of nitrates in natural sea-water is so low (Brandt, 47) that the amount available in a culture of untreated water very soon becomes completely exhausted, and it is this deficiency that sol. A probably corrects.

Considering now the action of sol. B, it must first be observed that increased concentration of nitrates alone will not explain the whole

* Loeb, *The Dynamics of Living Matter* (New York, 1906), p. 77.

† For the sake of convenience, the expression sol. A will be used throughout the rest of this paper to indicate a simple solution of potassium nitrate (5 per cent) and sol. B to indicate Miquel's phospho-ferricalcic solution (p. 423). Unless otherwise stated, the amounts of each added to 1000 cc. sea-water will be normal, i.e. 2 cc. sol. A and 1 cc. sol. B.

action of Miquel's solutions, for no increase in growth is obtained when nitrates or sol. A only are added to sea-water. To illustrate this point an account of an actual experiment may be given :—

Inoculated with *Thalassiosira decipiens.*

A. Normal Miquel sea-water.
  Good strong culture, in every way normal.
B. Outside water sterilized.
  Small growth at first; very soon exhausted.
C. Ditto + sol. A.
  No improvement over B.
D. Ditto + sol. B.
  Fair growth. Great improvement on B and C, but exhausted considerably before A.
E. Tank-water sterilized.
  Appreciably better than B, but growth not large.
F. Ditto + sol. A.
  Not even as good as E.
G. Ditto + sol. B.
  Next best in series to A; lasted longer than D, and had better colour.

To generalize, no improved culture is obtained with sol. A alone, but a fair, though not very lasting, growth can result from using sol. B only.

The action of sol. B is to some extent obscured by the fact that, when this solution is added to the alkaline sea-water, a precipitate is formed. This precipitate is at first white, but, on heating or standing for some time, it becomes greenish yellow. We are indebted to Mr. D. J. Matthews for the following analyses.

Ten litres of normal Miquel sea-water were prepared, and the precipitate was collected on a filter paper washed and dried at 100° C.

Weight of dry precipitate from 10 litres = 0·2949 grm.

Analysis of Dry Precipitate.

	Per cent.
P_2O_5	26·36
Fe_2O_3	41·31
CaO	7·63
H_2O	24·86
	100·16

Or, the precipitate from 1 litre of normal Miquel sea-water contains :—

P_2O_5	·00777 grm.
Fe_2O_3	·01218 „
CaO	·00225 „

An analysis of 1 cc. Miquel sol. B, the amount added to 1 litre Miquel sea-water, gave :—

P_2O_5	·00825 grm.
Fe_2O_3	·0105 „
CaO	·0145 „

Comparing these figures, it seems probable that, when added to sea-water, all the iron in sol. B is precipitated, and a certain amount also of the phosphate and calcium. The additive effect on the sea-water is therefore a slightly increased concentration of phosphate and calcium.

An analysis of a sample of tank-water for phosphorus, before and after treatment with sol. B (1 cc. per thousand), gave the following figures :—

Tank-water . . .	·5 mgrm. P per litre	= ·00163 grm. P_2O_5
Tank-water + sol. B (without precipitate) .	1·5 „ „ „	= ·00488 „ „

It will be noticed that the figures from the different analyses do not agree very well. This is probably due to the fact that different samples were used for analyses in each case, and also to the fact that the solutions were made up in the ordinary way, without any special precautions, volumes, for instance, being measured in cylindrical glasses, pipettes, etc.

Cultures were tried in sea-water containing the normal amount of sol. A, plus the normal constituents of sol. B, less all the iron and less the amount of phosphate that would combine with the iron to form basic ferric phosphate ($P_2O_5 2Fe_2O_3 12H_2O$). This solution should have very nearly the same chemical composition as normal Miquel sea-water from which the precipitate has been removed. Successful cultures could not, however, be obtained in it. Neither could cultures be grown in sea-water to which had been added the normal amount of sol. A and 1 mgrm. P (as sodium phosphate) per litre.

To ascertain the effects of the different constituents of sol. B, experiments were carried out with separate solutions of these constituents, each of the same strength as in Miquel's formula. Different combinations of these solutions were added, together with sol. A, to sterilized sea-water, and the resulting media were inoculated in the usual way. It was found necessary to repeat these experiments a great number of times, as the results obtained were rather contradictory. To illustrate the methods used, a list of the different media, and notes on the cultures obtained in them, are given below. These media were inoculated from cultures of *Thalassiosira decipiens*, and the

cultures were kept under observation for at least four months. Series were made as uniformly as possible, and controls in standard media were included in each. The strength of the various solutions used in these experiments was the same as in Miquel's formula.

A. Outside water + sol. A + sol. B (normal Miquel sea-water).
First control.

B. Outside water + sol. A + Na_2HPO_4 sol. + $FeCl_3$ sol. + $CaCl_2$ sol.
Second control.
Good normal cultures were always obtained in these two controls.

C. Outside water + sol. A + Na_2HPO_4 sol.
A very uncertain medium. Sometimes no growth has been recorded and at other times a fair growth results, but these cultures are never equal to normal Miquel.

D. Outside water + sol. A + $FeCl_3$ sol.
Occasionally a very small growth has been obtained, but at the best it is very poor.

E. Outside water + sol. A + $CaCl_2$ sol.
About equal to D.

F. Outside water + sol. A + Na_2HPO_4 sol. + $FeCl_3$ sol.
Uncertain as C; no cultures have been obtained equal to the best in C.

G. Outside water + sol. A + Na_2HPO_4 sol. + $CaCl_2$ sol.
Some cultures very nearly equal to the controls have been obtained in this medium.

H. Outside water + sol. A + $FeCl_3$ sol. + $CaCl_2$ sol.
Poor, about equal to D.

Analysing the above results, we see that—

(1) None of these modifications of sol. B give results equal to sol. B itself.

(2) The best result is obtained from the combination of the phosphate and calcium chloride solutions.

(3) Of the solutions used singly the phosphate is the best, the iron and calcium chloride being about equal.

(4) The addition of $FeCl_3$ to Na_2HPO_4, or the addition to $CaCl_2$ to $FeCl_3$, does not improve the medium to any extent.

Experiments were also made to determine whether the precipitate thrown down in sea-water by Miquel's sol. B, itself had any influence on culture media. A quantity of this precipitate was prepared, filtered off, and then added to outside sea-water + sol. A (nitrates). A small growth was obtained, which was a distinct improvement on the control without the precipitate, but exhaustion soon set in.

Further discussion of the mode of action of sol. B, and as to whether that action is purely nutritive, or partly nutritive and partly

protective, is better postponed until a later section, after the action of animal charcoal and other substances has been considered (see p. 455).

Animal Charcoal and Peroxide of Hydrogen. The most successful culture medium for plankton diatoms, next to Miquel sea-water, is that prepared from animal charcoal (cf. p. 435). Animal-charcoal water gives at first almost as good cultures of plankton diatoms as Miquel sea-water, but the tendency to paleness and exhaustion appears much sooner. The best cultures were obtained in "Berkefeld water," that is, tank-water from the Plymouth Aquarium treated with powdered commercial animal charcoal and filtered through a Berkefeld filter. Tank-water as a basis for animal-charcoal water is very much better than outside water, probably on account of the higher concentration of nitrates, etc.

There is a very striking resemblance between the effect of animal charcoal and of Miquel's sol. B upon sea-water used for diatom cultures, and the growths obtained by using tank-water + sol. B and tank animal-charcoal water are very similar in character. If Miquel's sol. A is added to animal-charcoal water, there is a great improvement, both in the colour and quantity of diatom growth, and in the case of *Thalassiosira decipiens* the chains are long and well formed. With animal-charcoal water + sol. B, on the other hand, practically no growth was obtained.

It is possible that a certain amount of phosphate, and perhaps of calcium, from the animal charcoal, goes into solution and serves as a "nutritive" material for the diatoms. But we are inclined to think that its chief action is "protective," and due to its power of occluding gases, such gases being in a state of higher chemical activity than under normal conditions.*

As was explained in a previous section (p. 434), the possibility that the action of animal charcoal might have some sort of effect comparable to oxidation, led us to experiment with hydrogen peroxide. Fair growths of diatom could be obtained in sea-water prepared in the manner described, but they always showed a tendency to rather rapid exhaustion. As in the case of animal-charcoal water, tank-water proved a much better basis for treatment with H_2O_2 than outside water.

Reviving Exhausted Cultures. Several experiments were carried out with water from old, exhausted cultures. The sediment was filtered

* Against this view would seem to be the fact, that when powdered cocoanut charcoal, which has a still higher power of occluding gases, was used in the place of animal charcoal, very poor cultures were obtained.

off, the filtrate was sterilized by heat, and then treated by various methods.

In one typical experiment the following was the result:—

Water from an exhausted culture of *Skeletonema costatum* in Miquel sea-water, reinoculated with the same diatom:—

A. Filtered and sterilized.
   No growth obtained.
B. Ditto + sol. A (nitrates only).
   Good culture, but did not last very long; further addition of nitrates made no improvement.
C. Ditto + sol. B.
   No growth.
D. Ditto + sol. A + sol. B.
   Very good growth, lasting considerably longer than B.
E. Ditto + an. char.
   No growth.

Exhausted cultures in animal-charcoal water gave the same general results on treatment and reinoculation. In an old culture of *Biddulphia mobiliensis* in outside water + sol. B only, which was in a very exhausted condition (nine months old), the addition of KNO_3 gave a very rapid regeneration, and the diatoms became of normal colour and form. This renewed growth, however, did not last very long, and a further addition of KNO_3 did not give any result. The addition of sodium phosphate also failed to stimulate growth. The same rapid regeneration, on the addition of potassium nitrate, has been obtained with almost every medium, but a second attempt has always failed.

Silica. A very noticeable character of the true plankton species of marine diatom is, that their skeletons are very markedly less silicious than the great majority of other forms. Their valves are only feebly marked, if at all, and they will not stand the vigorous treatment of cleaning with acids and heat that is commonly used in the case of fresh-water diatoms. In cultural forms, this absence of silica is still more obvious, and no marking can usually be seen on even those forms which, under natural conditions, are the most silicious, e.g. *Coscinodiscus excentricus.* Deformed and distorted frustules are the rule in certain stages of growth in our cultures, and it is often very hard to make out more than the thinnest coating of silica. It is quite probable that this deformity can be accounted for simply by the absence of a strong silicious skeleton. As a rule, the more rapid the growth, the more teratological forms will be found. In untreated outside water little deformity will take place, but in normal Miquel, where very rapid growth takes place, the diatoms may assume almost

any conceivable shape. The form of the frustules tends to come back to the normal again, when the culture is well started, and in old stages the majority will be perfectly formed, although small and pale. It was found that the addition of silica (in early experiments as fragments of potassium silicate) was, as far as could be judged, immaterial, which fact led to the conclusion that a sufficiency dissolved out from the glass flasks in which the cultures were kept. During rapid growth, it is possible that the silica does not dissolve out fast enough to supply the demand, although it is also possible that diatoms, during rapid division, cannot absorb silica and form a perfect skeleton, even when the supply is abundant. Richter (18) has proved the necessity of either $CaSi_2O_5$ or $K_2Si_2O_5$ for the growth of *Nitzschia palea*, grown in pure cultures. We tried the addition of silica in various forms, and in one instance, in a culture of *Coscinodiscus excentricus*, to which a little precipitated calcium silicate had been added, the uniformity and markings of the valves were much more regular than in the control. The presence of a trace of pure, dialysed silica, also, in one experiment, gave an improved regularity of form, but the quantity or rapidity of growth did not seem to be affected. No sign of regeneration could be obtained in exhausted cultures by the addition of silica.

Organic Infusions.—Miquel recommends the use in culture media of infusions of organic substances such as bran, straw, diatom broth, etc., in addition to the saline solution. He does not make it quite clear if he ever dispensed with them at all. In his general directions, he certainly states that the addition of both saline and organic nutrient material is necessary. As would be expected from the general metabolism of plants, the saline constituents are sufficient for growth. At the same time, excellent cultures have been obtained from dilute organic infusions, both with and without the addition of Miquel's sols. A and B. About a square inch of Ulva was boiled in 600 cc. sea-water for half an hour, cooled and filtered. In this medium an excellent growth of *Coscinodiscus excentricus* in one case, and *Biddulphia mobiliensis* in another, was obtained, the growth lasting for some considerable time.

Infusions, made in the same way from a small piece of fresh fish, gave the same results, and although growth was rather slower at first, the final result was, if anything, slightly better. As Miquel points out, these infusions must be made very dilute, otherwise growths of bacteria, moulds, etc., will completely swamp the diatoms. Karsten (7), in some interesting experiments, showed that *Nitzschia palea* (Kutz), W.Sm., could be made to alter completely its mode of nutrition. On placing this diatom in organic nutrient solutions, it lost all chloro-

phyll and became colourless, but in saline media the chlorophyll would not regenerate, and the nutrition change back from heterotrophic to autotrophic.*

Of course, with our infusions, it cannot be said that the diatoms were necessarily feeding on dissolved organic material, as some necessary, saline, nutritive materials could have dissolved out from the weed or fish. If the former is the case, it might explain the superiority of tank-water over outside water, since the tank-water must contain a much higher percentage of organic substances in solution. If an alternative mode of nutrition autotrophic or mixotrophic could be proved, especially in the case of the "bottom" forms of diatoms, a great many phenomena could be explained, but the evidence is as yet far too slight to warrant any such assumption.

Artificial Sea-water.—As we have explained in a previous section, the ideal aimed at, in this part of our work, has been to obtain strong growths of diatomaceae in purely artificially prepared solutions of simple salts. If this end could be satisfactorily attained, the difficulties due to the unknown and variable composition of natural sea-water at once disappear. According to van 't Hoff (35) sea-water is a solution containing salts in the following molecular concentrations:—

$NaCl$ 100·0, KCl 2·2, $MgCl_2$ 7·8, $MgSO_4$ 3·8, $CaCl_2$ 1·0 (varies).

Using these molecular concentrations, a sea-water of any desired salinity can be prepared. The chlorine content of average Atlantic water is about $Cl = 19{\cdot}4$, and samples of artificial sea-water were prepared with the same chlorine value, thus:—

$NaCl$	26·75
KCl	·75
$MgCl_2$	3·42
$CaCl_2$	·51
$MgSO_4$	2·10
Double-distilled water	966·47
	1000·00

To make this solution comparable to natural sea-water, the "alkalinity" must be raised by the addition of an alkali such as Na_2CO_3. After the importance of "alkalinity" as a factor had come before our notice, 2·4 cc. $M/_2$ Na_2CO_3 was always added to the above solution in order to make the amount of base in equilibrium with CO_2 equivalent to the usual 40 mgrm. OH °/$_{oo}$ (p. 450).

* Cf. Zumstein, *Zur Morphologie u. Physiologie d. Euglena gracilis.* Leipzig. 1899.

The only success we attained with artificial sea-water as a basis for culture media was with four isolated cultures in one of our earlier experiments. Two of these were cultures of *Coscinodiscus excentricus* in artificial sea-water + Miquel's solutions A and B. The two cultures were identical except that one was in an ordinary Bohemian glass flask and the other in a "resistance glass" flask. No difference between these two could be seen. The growth obtained in both was in every way equal to normal Miquel sea-water, and is still fair, although over two years old. The other two successful cultures were growths of the same diatom in the same media, plus a small quantity of weed infusion, made by boiling up a small piece of *Ulva* in artificial sea-water. These gave just as good results, but the addition of unknown factors from the weed detracts from their general interest. In spite of frequent attempts, over fifty in number, we have not been able to repeat this experiment, which may possibly be due to some accidental impurity in the salts or distilled water from which the successful media were prepared.

Alkalinity. Tornöe (43) and Dittmar (33) were the first to investigate the fact that sea-water showed on analysis an apparent excess of base over acid, which excess they termed "the alkalinity of sea-water." Dittmar defines the alkalinity of sea-water as "a measure of its potential carbonate of lime," but this definition, and his supposition that this excess of base combines directly with dissolved CO_2 to form carbonates and, further, but only in very small proportion, bicarbonates, is liable to give a quite erroneous idea of the state of equilibrium actually occurring in the ocean. For, as Fox (34) has shown, "sea-water reacts *in situ* very nearly neutral, and actually just slightly more *acid* than distilled water." This is due to the fact that sea-water always contains a considerable quantity of dissolved CO_2.

If a salt solution with *neutral* reaction, that is containing $H^{\bullet}$ and OH' ions in concentrations equal to one another and the same as for pure water, be exposed to an atmosphere containing CO_2, a definite amount, depending on pressure, temperature, and salinity, would go into solution. This CO_2 would combine with water and form the very weak acid H_2CO_3, which would ionize with the formation of the free $H^{\bullet}$ ions thus:—

$$H_2CO_3 \rightleftarrows H^{\bullet} + HCO'_3.$$
$$(HCO'_3 \rightleftarrows H^{\bullet} + CO''_3).$$

The second stage of dissociation is so small as to be negligible. The concentration of $H^{\bullet}$ being now increased, and OH' decreased, the

solution would have an acid reaction. The actual amount of CO_2 thus dissolved would always be small; for instance, a salt solution of strength Cl = 20·00 (average Atlantic water Cl = 19·4) will at 10°C. dissolve about ·3 cc. CO_2 per litre from an atmosphere containing 3 °/₀₀₀ CO_2 (about normal). But the ocean is found to contain very much greater quantities than this, 60 cc., or two hundred times this amount, being a not unusual figure for the total CO_2. The difference between this amount and the ·3 cc. or so dissolved by the neutral salt solution, as above, is kept in equilibrium with the 3 °/₀₀₀ CO_2 of the atmosphere, by the amount of "excess" base equivalent to the amount of acid neutralized when an acid such as HCl is added to sea-water in excess. If a solution identical with sea-water but absolutely free from CO_2 (a practical chemical impossibility) could be obtained, then there would be present an excess of base over acid, and consequently an excess of OH' ions over $H^{\bullet}$ ions, and an alkaline reaction. On exposing such a solution to the atmosphere, CO_2 would go into solution, ionize, and the $H^{\bullet}$ ions thus set free would react with the OH' ions, due to the excess base, to form water. And this reaction would continue to take place, on more CO_2 dissolving, until all the excess OH' ions were neutralized, at which point the solution would react neutral. Now, as before with the neutral salt solution, a further small amount of CO_2 would go into solution, bringing the solution into equilibrium with the atmosphere, and the excess $H^{\bullet}$ ions thus formed would give an acid reaction. The final result would be a solution exactly identical with natural sea-water. The total CO_2 found in sea-water can be considered as existing in two parts: the larger part in equilibrium with free base, its amount depending on temperature, pressure, and alkalinity; the smaller in equilibrium with the partial pressure of CO_2 in the atmosphere, its amount depending on temperature, pressure, and salinity. Although sea-water *in situ* has an acid reaction, it still maintains the property of being able to neutralize a certain amount of any acid stronger than H_2CO_3, that is any acid which, on dissociation, forms a higher concentration of $H^{\bullet}$ ions; for the stronger acid will turn out the H_2CO_3 in equilibrium with the "excess base" and CO_2 will be evolved.

In consideration of these points a less confusing definition of the "*alkalinity of sea-water*" would perhaps be *a measure of its potential capability of neutralizing a strong acid* with the evolution of CO_2*. This can be conveniently expressed, as is usual, in mgrm. OH °/₀₀.

Some of our earlier experiments seemed to show that "alkalinity" was a factor of considerable importance for the successful growth

* Such as HCl, with a high degree of ionization.

of cultures of plankton diatoms; so an attempt was made to analyse the various samples of water both before and after treatment as culture media. The method adopted was a modification of that used by Tornöe and Dittmar. Solutions of NaOH and H_2SO_4 of strength $N/_{50}$, by intention, were made up and stored in 5-litre "aspirator" bottles. Two accurately graduated burettes standing side by side were connected to these by tubes, so that they could be readily filled by gravity. All air inlets to burettes and stock bottles were fitted with tubes of soda lime. A standard solution of Na_2CO_3 of exactly known alkalinity, approximately that of average sea-water (40·00 mgrm. OH °/₀₀), was prepared by diluting down from a $N/_{10}$ solution, all operations being performed by weighing. These standards were stored in stoppered bottles of the fairly insoluble dark green glass, but those that had been kept for any length of time were not trusted, fresh standards being prepared. On analysis these standards agreed with one another to well within ·1 mgrm. OH °/₀₀. The water used for diluting the standards was distilled water from the laboratory still, redistilled in all-glass apparatus with potassium bichromate and sulphuric acid.

When carrying out an analysis, equal volumes (about 100 cc.) of sample and standard were measured out into Jena glass Erlenmeyer flasks with a Knudsen automatic pipette. The specific gravity of each was determined by weighing in a 25 cc. pyknometer. Sample and standard were then titrated by running in acid from the burette and back titrating with alkali, using a 1 % alcoholic solution of aurine as an indicator and keeping the liquid boiling. The acid to alkali equivalent was determined by titrating a pipetteful of double-distilled water in the same manner. The mean of at least four readings was always used. Let N and n be number of burette divisions of alkali equivalent to standard and sample respectively, and D and d their density at the time of pipetting out. Then if A is the alkalinity of the standard and X the required alkalinity of sample :—

$$X = A\frac{Dn}{Nd}$$

Since all operations were carried out at the same room temperature, no corrections for temperature are necessary.

In spite of the greatest care consistent results could not be obtained by this method of analysis. A sample analysed against the same standard would sometimes give results varying as much as 0·5 mgrm. and occasionally 1·0 mgrm. OH °/₀₀. The work on indicators by Salm (42) and its application to this question has only recently come to our notice, and it is our intention to experiment on this in future research.

The figures quoted below as the results of analyses have been rounded off as whole numbers, since their interest lies in their comparative rather than their absolute value, for convenience they are quoted as "alkalinities," although we are fully conscious that the methods used do not warrant this assumption, and that their actual chemical significance is still obscure.

The mean value for "outside water" was found to be fairly constant at 40·0 mgrm. OH °/₀₀, which figure agrees with results obtained by others for average ocean water. Samples from the aquarium tanks never gave as high figures as this, the average being approximately 37·5 mgrm. OH °/₀₀. From this it seems that the amount of base in equilibrium with CO_2 in tank-water is appreciably less than in outside water. A series of thirteen samples taken from seven miles beyond the Eddystone to well inside the Cattewater (an inner tidal harbour near Plymouth) showed a gradual lowering of the alkalinity from the normal 40, to 38 mgrm. OH °/₀₀ as the water became more estuarine and polluted.

The addition of Miquel's sol. B to sea-water was found, on analysis, to reduce the "alkalinity" by an amount equivalent to 10 mgrm. OH °/₀₀ or more. The 1 cc. sol. B added to a litre of sea-water, in itself contains a certain amount of free acid, equivalent to less than 4 mgrm. OH °/₀₀. But this reduction of alkalinity cannot be accounted for by the addition of free acid alone, because if only a quarter of the amount of sol. B is added, the alkalinity of the sample will be found to be, if anything, only very slightly higher. Also, if the various constituents of sol. B are added as separate solutions, thus obviating any addition of free acid, a reduction equivalent to about 6 mgrm. OH °/₀₀ is still obtained. The presence of ferric chloride in sol. B gives a possible explanation of this phenomenon. If a solution of ferric chloride is added to a solution of a soluble carbonate, a reaction, which can be expressed by the following equation, takes place:—

$$3\ R_2CO_3Aq. + Fe_2Cl_6Aq. = 6\ RCl.Aq. + Fe_2O_3Aq. + 3\ CO_2.$$

When the ferric chloride is added to sea-water, the final result will be that a certain amount of the "excess base" which was in equilibrium with CO_2, will then be in equilibrium with the chlorine, available on the precipitation of hydrated ferric oxide, with a consequent liberation of CO_2, and a reduction in "alkalinity" will, therefore, take place.

An analogy between the actions of Miquel's sol. B and animal charcoal can be seen in the fact that water treated with animal charcoal also shows a reduced "alkalinity," the amount being very variable in different samples.

Sea-water treated with H_2O_2 also showed a lowering of the alkalinity, but in a much less degree when, as usual, minimal quantities were used.

Control experiments on double-distilled water, which had been treated with these substances, were tried, but great difficulty was found in obtaining an end point with the indicator. As far as could be judged, distilled water treated with sol. B (quantities as with sea-water) showed a negative "alkalinity," equivalent to about 8 mgrm. OH °/₀₀, and in the case of animal charcoal a positive alkalinity equivalent to 6 mgrm. OH °/₀₀, but the colour change was so slow that these results are only the roughest estimates. The possibility that the above results are due to some effect on the indicator, which entirely cloaks the true alkalinity, must always be taken into consideration.

Before any attempts at analysis had been made, the probability that considerable differences might be found in the alkalinity of the various media had presented itself. Improvement in the growth of diatom cultures was found to result from the purely empirical addition of $NaHCO_3$, this result being most marked in normal Miquel sea-water, outside water + sol. B only, and Berkefeld water. No growth could be obtained in either tank-water or Miquel sea-water to which had been added 1 cc. HCl (pure, concentrated) per litre, but on again raising the alkalinity of the latter by the addition of $NaHCO_3$ or KOH good normal growths resulted. Richter (18) and H. Gill (5), also, both state that a weak alkaline reaction is necessary for the growth of diatoms.

In our most recent experiments, all the media have been analysed for alkalinity, and those given in detail below illustrate the importance of determining this factor. Cultures of *Thalassiosira decipiens* were made in the following media:—

A. Tank-water. Control.
Poor growth, hardly normal. Later, good growth of minute forms, etc.

B. Tank-water treated with cold commercial animal charcoal and filtered.
Very good growth indeed.

C. Tank-water treated with cold *pure* an. char. and filtered.
Very poor growth, comparable to A without minute forms.

D. Tank-water treated with pure an. char. as in C, but the an. char. was added red hot.
Fair growth, much superior to C, but not up to B.

The sample of pure an. char. used here had been previously found to give very poor results, and it was also quite contrary to our experience that any improvement in growth should be obtained by adding it hot.

But if we examine the results of analyses of these media for alkalinity a probable explanation presents itself. The following figures are only comparative:—

A—38 mgrm.	OH °/₀₀		(used as standard).
B—37	„	„	(higher than usual).
C—16	„	„	(very low indeed).
D—34	„	„	

It will be seen that the amount of growth in each treated sample follows the alkalinity very closely.

Solutions of Na_2CO_3, $NaHCO_3$ and HCl were made up, so that 4 cc. of any one contained an amount of acid or alkali equivalent to 10 mgrm. OH. From these a series of normal Miquel sea-waters of different alkalinities were prepared. Cultures of *Thalassiosira decipiens* were grown in these media.

A. Normal Miquel sea-water. Control. A = 32·7 mgrm. OH $^{\circ}/_{\circ\circ}$.
Perfectly normal growth.

B. Ditto + 4 cc. Na_2CO_3 per litre. A = 41·7 mgrm. OH $^{\circ}/_{\circ\circ}$ (= + 9·0).*
No difference between this culture and A.

C. Ditto + 8 cc. Na_2CO_3 per litre. A = 50·2 mgrm. OH $^{\circ}/_{\circ\circ}$ (= + 17·5).
Best culture in series in quality and quantity.

D Ditto + 4 cc. $NaHCO_3$ per litre. A = 42·4 mgrm. OH $^{\circ}/_{\circ\circ}$ (= + 9·7).
Slightly better than control.

E. Ditto + 8 cc. $NaHCO_3$ per litre. A = 51·5 mgrm. OH $^{\circ}/_{\circ\circ}$ (= + 18·8).
As D.

F. Ditto + 4 cc. HCl per litre. A = 22·2 mgrm. OH $^{\circ}/_{\circ\circ}$ (= − 10·5).
Fair growth but never up to control, exhausted much sooner.

G. Ditto + 8 cc. HCl per litre. A = 11·1 mgrm. OH $^{\circ}/_{\circ\circ}$ (= − 21·6).
Poorest in series.

Except in the cases where the alkalinity was lowered by the addition of HCl, the results obtained from this series were not up to expectation. Nevertheless the majority showed a distinct improvement from increased "alkalinity" and in C, where the alkalinity had been raised 17·5 mgrm. OH $^{\circ}/_{\circ\circ}$, this improvement was very marked.

Another point illustrated by cultural experiment is that in two samples of an. char. water, one with "outside" and the other with "tank-water" as a basis, the amount of growth in the latter considerably exceeded that in the former, and at the same time it was found that, with the tank-water, the alkalinity had not been reduced to the same extent as in the case of the outside water.

How far apparently anomalous results, which have so frequently

* Figures in parentheses are difference in alkalinity from control, in mgrm. OH $^{\circ}/_{\circ\circ}$.

occurred in our experimental work, could be explained by unforeseen changes in "alkalinity," can only be answered by future research.

Salinity.—The salinity (or amount of salts dissolved in a litre of sea-water) of the outside water used in these experiments only varied between small limits, $S = 34{\cdot}5 - 35{\cdot}5°/_{oo}$. The salinity of "tank-water" is also fairly constant, the average being about $S = 34{\cdot}9°/_{oo}$; water is only pumped up into the reservoirs at high water, spring tides, and unless the salinity on analysis is well above $S = 34{\cdot}5°/_{oo}$ no water is taken. Experiments to show what effect salinity pure and simple had on the growth of diatoms were undertaken. Samples of sea-water of various salinities were prepared by diluting down "outside water" with double-distilled water, and by concentrating "outside water" by slow evaporation. Two litres of "outside water" $S = 34{\cdot}9$ were evaporated down to the bulk of one litre, giving a 50%* concentration. Miquel solutions 4 cc. A, 2 cc. B, were now added, and the solution was divided into ten culture vessels, 20 cc. in each. Double-distilled water was added, 2 cc. to the first, 4 cc. to the second, 20 cc. to the last, so that a series of media were obtained, varying in salinity from normal to nearly 50% concentration, each containing the same amount of Miquel's nutrient solutions. These were inoculated from a mixed culture of *Skeletonema costatum*, *Biddulphia mobiliensis*, and *Coscinodiscus excentricus*. A good growth took place in all except the two with highest concentration. Of these two, the last remained practically sterile and the growth in the other was very poor. The limit of concentration, therefore, seems to lie between 35 and 40%. In the same way series of lowered salinities were prepared, and cultures of the same diatoms were grown in these. Dilution up to 100% did not seem to make any difference at all in the quantity or quality of growth. In a series extending the dilution to 200% even in the cultures of lowest salinity, a fair quantity of growth took place. The range of salinities covered by the various series was $S = 12°/_{oo}$ to $S = 60°/_{oo}$ and within these limits no effect on growth could be observed, except in the very highest, where a distinct deterioration was noted.

An attempt to grow *Coscinodiscus excentricus* in tap water + Miquel's solutions was tried, and it was thought that some slight multiplication took place, although it was certainly not at all considerable. Inoculating a culture of normal Miquel sea-water from this after six weeks gave no growth.

Light. Of all the factors controlling the rate of growth of a culture,

* i.e. from every 100 cc. sea-water 50 cc. H_2O had been subtracted.

light seems to be by far the most important. Without light a culture soon dies off completely, showing marked signs of malnutrition very soon after having been placed in the dark, the brown pigment being the first to go, and later the chlorophyll. A culture (*Thalassiosira*) placed in the dark for five months was found to be completely killed, the diatoms being quite colourless. In cultures kept in bulbous flasks or any spherical vessel, the strongest and earliest growth always takes place at the side of the vessel away from the source of light, where the light will be found to be concentrated owing to the lens effect of a sphere of water. By painting a flask black on the outside up to the water-line of the medium, a very marked diminution in the *rate* of growth was obtained. The total growth was not affected, but depends on the available quantity of food-stuffs present.

Experiments on the reaction of cultures to different rays of the spectrum, obtained by coloured glass, were tried, but no results obtained. Miquel obtained marked results with yellow light, but in our experience, with plankton diatoms, satisfactory cultures could not be obtained under these conditions.

Temperature. The highest temperature which diatoms and allied forms can stand was about uniform for all the species tested, and lay between 35°–40° C. Cultures of the following species, viz. *Asterionella japonica*, *Nitzschia closterium*, minute naviculoid diatom, *Pleurococcus mucosus*, *Chilomonas* sp., were slowly heated in a water bath, and at every rise of 5° C. from 15° C. to 45° C., a few drops of the culture were pipetted out and a fresh flask inoculated. In all the flasks cultures were obtained where the heating process had not been carried above 35° C., but none in those where the temperature had exceeded this.

In the earlier stages of experimentation the cultures of diatoms were kept in various places about the Laboratory, and so were under quite different temperature conditions. Those placed in the warmer situations, i.e. near hot-water pipes, as a rule gave the most satisfactory results. In all the later work the cultures have been kept in one room, and an attempt has been made to keep the temperature of this room as nearly as possible constant at 15° C. A continuous record of its temperature has been kept by means of a recording thermograph, and no very great change of temperature has been noted. In a few isolated cases the temperature has dropped as low as 9° C., and in hot weather has risen just above 20° C., but these have only been for very short periods, the average temperature having kept remarkably constant. An apparatus in which flasks could be kept at

different uniform temperatures from 10° to 25° C., by means of hot air, was used, but no really satisfactory result could be obtained. About 17° C. seemed to give the maximum growth, and the cultures below this temperature were usually superior to those above.

General Conclusions. The general conclusions to be drawn from the experiments described in this section, which were made with a view to determining the conditions that underlie the successful culture of diatoms, may now be discussed. Although the experiments have involved the making of some 750 different cultures, our conclusions on many of the questions raised are still indefinite, and much further work will be necessary before a satisfactory answer can be given to them.

If we wish to obtain the maximum quantity of healthy growth of a plankton diatom, the diatom must first be obtained as free as possible from all other organisms, if not in a "pure" culture, at least in a "persistent" culture. All culture media should be sterilized either by heat or filtration, and the experiments should be conducted under sterile conditions. Starting with normal sea-water as the basis for the culture medium, it seems to be first necessary to raise the concentration of the nitrates, and possibly also of the phosphates, in solution. But this simple addition of nutrient materials will not in itself suffice. Some other action, such as that exerted by Miquel's sol. B, by animal charcoal, or by peroxide of hydrogen, seems to be imperative in nearly every case. The exact nature of this action we have not been able conclusively to determine. If the substance contained in sol. B were purely nutritive in character, we should expect that, when alterations in the amounts of the different ingredients were made, or when any one of the ingredients was omitted altogether, the differences in the quantity of growth would show a direct relation to the kind of modification introduced. But our usual experience has been that sol. B can be modified within certain limits, without producing any appreciable effect upon the resulting cultures, whilst if these limits are exceeded, there is an almost complete inhibition of growth. In supplying a necessary increase of phosphates, both Miquel's sol. B and animal charcoal may and probably do act as "nutritive" substances, but, since the addition of phosphates alone does not yield cultures comparable with those produced by either of these, and since, excepting phosphates, there is no possible common nutritive substance in their composition, we are led to conclude that, in addition to any nutritive effect, they must exert some other action. This view is supported by the results obtained by using H_2O_2. This substance cannot be directly "nutritive," although it may be so indirectly, by oxidizing into useful

food-material substances which the diatoms are incapable of using in their metabolism, e.g. nitrites into nitrates. The absence of any increase in phosphates, when using H_2O_2, may possibly be the reason why better results were not obtained with this medium. The action which, in addition to any nutritive value, we must assume that sol. B, animal charcoal, and H_2O_2 can all effect, would appear to fall into the class of "protective" actions (p. 439). It is quite conceivable that, with different samples of sea-water, this "protective" action is not necessary in every case, and this would account for the anomalous results met with when using sea-water + nitrates + phosphates only, in which medium sometimes good cultures, but more often the reverse, are obtained. The effect of Miquel's sol. B, animal charcoal, and H_2O_2 on the "alkalinity" of the sea-water, also points to some chemical change, which does not directly enter into the metabolism of the plants.

It may be pointed out that the action of such substances as finely powdered carbon, and ferric oxide precipitates, has been shown to produce a favourable effect on nutrient solutions used for the culture of certain higher plants, and it has been suggested that the beneficial action of these substances is the removal of toxic elements from the media (Breazeale, 3). Such removal of toxins would fall under our definition of "protective" action.

Of nutritive substances, other than those already mentioned, we have still to consider (1) silica and (2) dissolved oxygen and carbonic acid. Having regard to the conditions under which our cultures have been grown, i.e. in glass flasks, the question of silica does not seem to enter into the problems which we have discussed. A few words must, however, be said as to the dissolved gases. Whipple (62) and Baldwin (44) have drawn attention to the observed relations, which are found in natural waters, between algal growths and the amounts of dissolved oxygen and carbonic acid. That these factors are of great importance cannot be doubted, but in our cultures it seems reasonable to suppose that the conditions of saturation of these gases are the same in all, since series of cultures in standard media, such as Miquel sea-water or Berkefeld water, can be set up with the certainty that, if not every one, at least a very high percentage, will give normal results.

Of the purely physical factors, light is by far the most important. Within limits, the rate of growth in a suitable medium seems to depend directly on the intensity of the light (Whipple, 60). Absence of light, as would be expected, soon completely kills the diatoms.

Temperature also seems to affect the rate of growth to a certain extent, but for those temperatures at which we have experimented it does not appear to alter the quantity of growth.

Salinity, apart from the quantities of available nutrient materials, can be varied within large limits without appreciable effect on the diatoms.

II. MIXED CULTURES.

In what has been said up to the present, we have been dealing with persistent cultures containing a single species of diatom, which are comparatively, if not entirely, free from admixture of other organisms. The study of cultures which contain a considerable mixture of organisms is not without interest.

A number of experiments have been made on the following lines. About 10,000 cc. of water, taken at some distance from shore, was placed in a tall bell-jar fitted with a "plunger," which keeps the water in constant movement. (*Journ. Mar. Biol. Assoc.*, Vol. 5, p. 176). The water was treated with Miquel's solutions in normal proportions, and a considerable quantity of plankton taken with a fine-meshed net (150 meshes to the inch) was added, say, 10 or 20 cc. of a moderately rich sample of tow-netting. The experiments were made during the spring and summer months, and the general course of events has been the same, with a certain amount of difference in detail according to the nature of the plankton present at the time.

During the first two days the water often became cloudy, owing to the rapid multiplication of small flagellate infusoria, though this was not always the case. Plankton Copepods and other animals gradually died off, though some survived for as long as a week or ten days. The plankton diatoms, on the other hand, generally multiplied rapidly during the early days of the experiments, the first to become abundant in the body of the water being usually *Skeletonema costatum*, which at the end of a week might be so thick, that a number of chains could be seen in every drop of water examined with the microscope. Along with the *Skeletonema* were found other plankton diatoms, such as *Lauderia borealis*, *Chaetoceras* (two or three species), *Biddulphia mobiliensis*, *Ditylium Brightwellii*, and in nearly every case *Thalassiosira decipiens*. These latter diatoms were present in moderate numbers only, when the *Skeletonema* was at its height; but as the *Skeletonema* died down they increased in quantity. At the same time *Nitzschia closterium* commenced to appear, both amongst the precipitate on the bottom of the jar, and in the general body of the water. Small green flagellates often began to get numerous also at this stage. The true plankton diatoms were at their height about a fortnight after the experiments were started. At this time a great many diatoms of all

kinds were to be found amongst the precipitate at the bottom of the jar, *Asterionella japonica* and *Coscinodiscus excentricus* being often numerous here. During the course of the next week, however, *Nitzschia closterium* rapidly increased in quantity until, not only the sides of the jar were coated with it, but the whole mass of the water became thick and opaque. By this time the plankton diatoms had all disappeared, with the exception of those which may survive for a considerable period amongst the precipitate at the bottom of the jar. Bottom diatoms (*Navicula*, etc.) had begun to grow on the sides of the jar, and small green and brown algæ (*Pleurococcus mucosus, Ectocarpus*, etc.) also appeared. Infusoria (*Euplotes* and other smaller forms) then became numerous, and as the *Nitzschia* and bottom diatoms increased on the glass, large numbers of *Amoebæ* made their appearance among them. The jars continued in this condition for many months, the algæ becoming more and more predominant.

From these experiments, as well as from instances of mixed cultures obtained in the course of our attempts to secure persistent cultures of single species of diatoms, it seems usual that, in a culture obtained by inoculating Miquel sea-water with plankton taken freshly from the sea, the true plankton diatoms are the first to develop in considerable numbers. Subsequently bottom diatoms and algæ of various kinds become abundant, and the true plankton forms die out.

A complete explanation of this sequence of events would probably be of a very complicated character, and we have practically no evidence from our experiments which bears very directly on the question. It would seem, however, that the early predominance of the plankton forms in the cultures would naturally follow from the fact that, in the plankton material used for inoculation, these plankton forms are numerous, whilst bottom diatoms and spores of algæ are rare. The subsequent very great predominance of such a species as *Nitzschia closterium* may be due simply to a very much more rapid growth rate, though it is difficult to avoid the impression that the organisms which finally take possession of the cultures, are in some way directly inimical to those which they supersede, not merely by robbing them of their food-supply, but perhaps, also, by the production of toxic substances. This suggestion does not, however, give an adequate explanation of the essential facts concerning these organisms. We have to consider two sets of species: (1) the true Plankton forms, which flourish in the open sea and can be grown quite easily in the laboratory, provided the cultures remain pure; and (2) what we may call "aquarium" or "bottom forms," which under experimental conditions invariably take possession, when present in mixed cultures, whilst the plankton forms

are killed off. Why is it that, although species of the second class are always present in small numbers in plankton taken from the sea, they are there altogether outnumbered by the true Plankton forms, whereas under conditions such as those of our experiments they invariably succeed in gaining the upper hand? What are the factors which determine the difference in behaviour of these two sets of organisms in the sea and in the culture vessels? The whole question offers a very fruitful field for further experiment. The evidence at present available is so slight that further discussion of it here is not likely to be of much service.

The details of two experiments which we have made, bearing on the subject of mixed cultures, may, however, be recorded.

A flask, containing about 1000 cc. of sea-water treated with Miquel's solutions, was inoculated with approximately equal amounts of certain persistent cultures of diatoms, which we possessed at the time. The following diatoms were in this way introduced:—*Chaetoceras constrictum*, *Biddulphia mobiliensis*, *Skeletonema costatum*, *Coscinodiscus excentricus*, *Streptotheca thamensis*. The flagellate (*Chilomonas* sp.) was also introduced, since it was present in the culture of *Coscinodiscus*. The experiment was started on August 26th, 1907. On September 6th (11 days) *Biddulphia*, *Coscinodiscus* and *Chaetoceras* were increasing rapidly and were very healthy. *Skeletonema* was not so good, and no *Streptotheca* was found.

On October 2nd (37 days) *Biddulphia* was numerous and healthy, *Coscinodiscus* was healthy but not so numerous. *Skeletonema* was poor, and *Chaetoceras* was not seen. Flagellates (*Chilomonas*) had become very numerous.

On October 31st (66 days) all the diatoms were in very poor condition, *Coscinodiscus* being slightly better than the others. The flagellates (*Chilomonas*) were extremely thick, giving the water a deep red colour.

Subsequently a small green alga (*Pleurococcus mucosus)* appeared, having probably been derived from the *Coscinodiscus* culture. This increased very greatly in quantity, whilst the flagellates became inconspicuous.

On July 28th, 1909 (1 year 11 months), some *Coscinodiscus*, which were still in a healthy condition, were seen in a sample examined from the flask. A great quantity of *Pleurococcus*, in a healthy condition, was also present, but no other organisms were noted. On this date a subculture was made from the flask in normal outside Miquel. The subculture gave a considerable growth of *Skeletonema*, the cells being, however, of a very abnormal character, and a good many normal and

healthy *Coscinodiscus* were found in each sample examined. The whole culture was crowded with *Chilomonas* in a very active state, which gave the whole contents of the flask a deep red-brown colour. Up to August 24th, the green alga (*Pleurococcus*) had not become sufficiently abundant to be detected by the naked-eye appearance of the flask, though it could be seen in samples examined with the microscope.

In another experiment, a flask of Miquel sea-water was inoculated (May 4th, 1908) from two cultures, one containing the green alga (*Pleurococcus mucosus*) and the other *Thalassiosira decipiens*. At first both did well, and on May 20th (16 days) there was a very good crop both of the diatom and the alga. Gradually, however, the alga became predominant, and on October 14th (163 days) only quite empty frustules of *Thalassiosira* could be found, whilst the growth of *Pleurococcus* was abundant and healthy. The only case where a diatom was observed to flourish in the presence of this green alga was in a culture of *Nitzschia*, a bottom form. In this case a very abundant growth of the diatom was obtained, but the *Pleurococcus* did not multiply to any extent, although it could always be found on microscopic examination.

III. NOTES ON PARTICULAR SPECIES OF DIATOMS, ON THEIR METHODS OF REPRODUCTION, AND ON OTHER ALGÆ OCCURRING IN CULTURES.

A list has been already given (p. 425) of those species of diatoms which we have obtained in "persistent" cultures. Of these, a species belonging to the genus *Thalassiosira* has been used for experimental work in the great majority of cases. We are not quite certain as to the identity of the species, but since it most resembles *T. decipiens*, Grun., we have called it by that name, although it does not exactly conform to the published descriptions of that form. The most characteristic feature of this particular species is the eccentric markings on the valves, which are also seen on the valves of the diatom *Coscinodiscus excentricus*, Ehr., and, as is typical of the genus, the frustules are united into chains by a delicate filament. Jörgensen (50, p. 96) describes the valves as "decidedly convex," Gran (49) as "flat," and both agree that there are marginal spines and a single asymmetrical spine. Our cultural forms are united together by a filament into chains, some of which are made up of five hundred cells and more, but the distance between each is considerably smaller than that figured by Gran. The valves are quite flat and the marginal spines are often

present, although this is not always the case. The odd asymmetrical apiculus can nearly always be seen. The eccentric markings have only been observed in a few isolated cases, and are then usually very indistinct. In one culture these markings on the valves were very distinct, and were also easily seen on the megafrustules (cf. below) which developed in it, but in none of the several generations of cultures started from this one have we been able to find any traces of marking at all. The genus seems to be in considerable confusion, and it is probable that the conflicting descriptions given by different observers are due to variations in what is really one species.

Persistent cultures of *Coscinodiscus excentricus*, Ehr., have also been obtained, and it is interesting to note that this diatom sometimes forms chains, but they are rather exceptional. These chains are never as long as those commonly found with *Thalassiosira*, two or four cells only being the rule. The filament joining the valves is also finer and more easily broken. The two species are quite distinct, and cultures of them can be discriminated by a practised eye.

Two species of the genus *Biddulphia* are commonly met with in our cultures, namely *Biddulphia mobiliensis* (Bail.), Grun., and *Biddulphia regia*, M. Schultze. These two forms are generally regarded as one species, but Ostenfeld (54) has recently shown that they are really distinct. We have obtained persistent cultures of both forms from several different samples of plankton, and the two species are easily recognizable, never merging into one another. When Petri dishes, inoculated from plankton (see p. 425), contain both species, the colonies can be easily distinguished with a small hand lens.

The most generally accepted theory of the reproduction of the diatomaceæ is briefly that the cells divide by simple fission, but on account of the rigid character of the cell walls each division necessitates a decrease in size of the new valve, since this must always be formed inside the old valve. So the frustules gradually get smaller and smaller as multiplication proceeds, thus necessitating some process by which the original size can be re-established. This takes place by the formation of what are known as auxospores, which ultimately form megafrustules, and these in turn multiply by division until the minimum limit of size has again been reached. There are also several special processes of reproduction, but no occurrence of any of these has been noted in our work (cf. Miquel, 14).

The diatoms in our cultures multiply by simple fission, and although there is, in nearly every case, a considerable diminution in size when compared with specimens from the plankton, this diminution soon

seems to reach a limit, where further decrease does not take place. In chains of *Thalassiosira*, several hundred cells in length, no difference in size between individuals could be made out. Auxospores are commonly formed with every species, but only in the cultures of *Coscinodiscus* and *Thalassiosira* have megafrustules been found, and in these they are very exceptional. These megafrustules seem to divide once or twice and then die or form new auxospores. What exactly is the fate of these auxospores, which are often exceedingly numerous, we have not been able to make out. It seems that cultural conditions are not favourable to this mode of reproduction, and that the auxospores do not further the multiplication of the diatom at all. If this were not the case, stages of the formation of auxospores into frustules must have been seen in some at least of the very numerous samples examined. As it is, what has been said to take place is, that the cell contents expand and force apart the valves of the diatom and emerge as a spherical body about three or four times the diameter of the parent cell. The chromatophores and diatomin then collect to one side, forming a compact cap against the cell wall. Beyond this point no stages have been found, except in the case of the few cultures where megafrustules were formed. In these the chromatophores, etc., gradually formed into the shape of the diatom (*Coscinodiscus*), the silicious coat with plain eccentric markings was easily seen inside the spore, and lastly, the cell wall of the spore burst, leaving the megafrustule free. The megafrustule was measured and found to have a diameter three times that of the parent cell.

In the case of the diatom we have very largely used for feeding larvæ, etc., namely *Nitzschia closterium, forma minutissima*, a great number of cultures have been made, all originating from the single drop from which the first persistent culture was obtained. The total amount of growth in all the various cultures has been enormous, and the number of generations must be quite inconceivable. No diminution in size has, however, been appreciable, and no sign of any method of re-establishment of size has been seen, although these cultures have been under constant observation for over two years. This seems to prove that the theory of gradual decrease in size with successive generations cannot be generally applied.

The following experiment on the rate of multiplication of *Thalassiosira* in normal Miquel sea-water was carried out. A single drop from a fresh and vigorous culture was kept under a microscope as a hanging-drop preparation in a moist chamber. The number of diatoms in this drop was counted from time to time, and the results are given in the following table:—

Day.	Number of frustules.	Geometric progression.
11th	59	63
14th	62	68
19th	85	85
27th	140	120
34th	170	160
41st	190	220

The curve obtained by plotting the number of diatoms against the number of days approximates the curve of an ordinary geometric progression, where the ratio is two and the periods are equal to sixteen days. To show this the figures read off from the curve at the same intervals as the diatoms are appended in the table. From this it will be seen that, after a start had been made and before exhaustion set in, the numbers obtained agree fairly closely with the assumption that every diatom divided once in a period of sixteen days. Probably in normal cultural conditions the rate of multiplication greatly exceeds this figure on account of better lighting, etc. (cp. Miquel, 12).

Besides diatoms, many other organisms appear in these cultures. We are indebted to Prof. G. S. West for the identification of a form of unicellular alga, which is very common and difficult to avoid when attempting to obtain persistent cultures of the *Diatomaceæ*, namely *Pleurococcus mucosus* (Kutz.), Rabenh. This small green alga, if once introduced into a culture of a plankton diatom, will soon multiply at the expense of the latter with its ultimate extinction. It is very hardy and cultures of it in almost every medium seem to last indefinitely. Multiplication beyond a certain point probably does not occur, but the cells retain their colour and normal shape and will start active reproduction if suitable nutrient material is provided.

In cultures inoculated from plankton many other forms of unicellular and filamentous algæ thrive. Several species belonging to the classes *Rhodophyceæ* and *Myxophyceæ* commonly occur, but we have not been able to identify them. The most usual filamentous forms of *Chlorophyceæ* are *Enteromorpha*, *Vaucheria*, *Rhizoclonium*, etc. It is interesting to note that it was the unintentional appearance of young plants of *Laminaria digitata* in some of our Petri dishes that led Mr. Drew (4) to cultivate this alga in Miquel sea-water and so discover its early life history. Cultivations of marine algæ by these methods would without doubt yield many new species, and would also provide rich material for the study of their modes of reproduction.

Many forms of flagellates live either together with diatoms or alone. Among these is an unidentified species of *Chilomonas* which we have obtained in persistent culture. It multiplies very rapidly, colouring

the whole medium a deep red-brown. It flourishes in Miquel sea-water, and its nutrition is evidently autotrophic. In one culture in Miquel sea-water inoculated with plankton a number of Coccospheres developed, probably *Coccosphæra atlantica*, Ostenf. Other flagellates and ciliated infusoria are very commonly met with, such as *Bodo*, *Euplotes*, *Euglena*, etc., which all seem to depend on the diatoms or other vegetable organisms for their food material.

IV. THE REARING OF MARINE LARVÆ.

In the rearing of pelagic larval forms of marine animals,* the principle which we have followed has been to introduce into pure, sterile sea-water the larvæ to be reared, together with a pure culture of a suitable food. As far as practicable all other organisms have been excluded from the rearing vessels. It should be added that the food used in all successful experiments has been of a vegetable nature, and has continued to grow actively in the vessels. This is important from the point of view of oxygen supply. Under the above conditions, or rather under the nearest approach to them at which we have been able to arrive, no change of water has been found necessary.

Methods.—It will, perhaps, best make the matter plain if we first of all describe the actual procedure which we now follow in the case of such an animal as *Echinus esculentus* or *E. acutus*. The water to be used is first of all prepared by treating water from the aquarium tanks with powdered animal charcoal, filtering it through a Berkefeld filter (p. 431), and collecting it in sterilized glass vessels. All instruments and pipettes are sterilized by baking in an oven, and a fresh sterile pipette is used for each operation during the progress of the work. Specimens of *Echinus* are then opened until a perfectly ripe female has been found, that is to say, one in which the eggs separate quite freely, when a portion of the ovary is shaken in sea-water.

Pieces of ovary taken from a little below the exposed surface are then placed in sterile sea-water in a shallow glass dish and shaken with forceps in order to get the eggs well separated, or a number of eggs from the centre of the ovary are drawn up with a pipette and placed in the water. A very small quantity of active sperm from a ripe male is then added, very little being sufficient to fertilize a large number of eggs. Excess of sperm should be avoided owing to its liability to putrefy. After an interval of ten or fifteen minutes the water containing the eggs is filtered through bolting silk of 100 meshes per inch, which just allows single eggs to pass through, whilst keeping

* See *Bibliography*; especially Grave (26), MacBride (28–30), Doncaster (25), etc.

back clusters of eggs or other large material. The filtrate is divided amongst a number of tall narrow beakers containing sterile sea-water, and the beakers, after being covered with a glass plate, are placed where the temperature will be uniform and not rise much above 15° C. In the course of twenty-four hours the healthy larvæ will swim up to the surface and can be easily seen and removed from vessels of this shape. They are transferred by means of sterile pipettes to jars* of sterile sea-water, about fifty to seventy larvæ being put in each jar of 2000 c.c. sea-water. At the same time, a good pipetteful of a pure culture of diatom is added to each jar. The small diatom *Nitzschia closterium, forma minutissima*, we have found most useful, as its size is suitable, and it grows well in animal-charcoal tank-water, floating throughout the body of the water, and so being in intimate admixture with the larvæ. The jars are placed in a moderate light and at as even a temperature as possible.† No further attention is necessary until the larvæ have metamorphosed. The metamorphosis takes place in from six to nine weeks after fertilization. Larvæ may be taken out from time to time and examined to see if they are feeding well. If the diatoms do not grow sufficiently rapidly in the jar, more should be added from the culture flasks. We are more often troubled, however, towards the end of an experiment by an excessive abundance of diatoms. In this case the jar may either be put in a darker place or some of the water may be drawn off and replaced by a fresh supply of sterile sea-water. Care should be taken to have a sufficient supply of food at the beginning of the experiment, so that the larvæ may be able to feed as soon as they are ready for food.

The method just described can be modified in various ways without detriment to the result. Sufficient sterilization of the water may be effected by heating to 70° C. for fifteen minutes, after which it should be aerated by violent shaking; "outside" water may be used instead of "tank-water," and may be treated with Miquel's solutions in the ordinary way, to ensure a satisfactory growth of the food-diatom.

With regard to the food organisms, we have tried to obtain as large a variety of these in pure culture as possible, and then to make trial of a number of them with each batch of larvæ on which we have experimented. If no suitable pure cultures are available, success can sometimes be obtained by adding a few drops of tow-netting, collected with a fine-meshed net (180 meshes per inch), directly to the treated

* The vessels we use are ordinary green glass sweet-jars, having a capacity of about 2000 c.c., which are kept covered with the glass stoppers provided with such jars, from which the cork band has been removed.

† In hot weather we often stand the jars in one of the tanks of circulating aquarium water, which maintains them at a very uniform temperature.

sterile water containing the larvæ. In this case one depends on the chance of a suitable food organism growing in the vessel unaccompanied by any destructive organism. On several occasions a satisfactory result has been reached by proceeding in this way, and the method is generally worth a trial, seeing that the number of larvæ obtainable from an ordinary fertilization is very large, and many different experiments are easily made with them.

We will now give details of some of the results obtained by making use of the methods described, or of their modifications.

Echinus acutus.—The first successful experiment was made with this species. Eggs fertilized on June 13th, 1905, produced healthy larvæ, 50 to 75 of which were placed, three days later, in a glass jar containing 2000 c.c. of outside sea-water, filtered through animal charcoal, to which modified Miquel solutions were added. They were fed on a diatom culture, containing a small species of *Chaetoceras*, which did not form chains, a small diatom probably belonging to the genus *Melosira*, a small Naviculoid diatom, two minute flagellates, and a small green organism, probably one of the *Pleurococcaceæ.* The vessel stood in a shallow tank, through which a stream of aquarium water was flowing, and the temperature was fairly constant at 15° or 16° C., though there is one record of 19° C. at the end of July. The first two young *Echinus* were seen on July 25th, 42 days after fertilization, and on August 1st 20 were counted. On August 5th (the 53rd day) a careful search through the jar gave 21 young *Echinus* of normal size attached to the glass, 6 minute but fully formed *Echinus*, about 23 still in the Pluteus stage, roughly half of which were well advanced. On August 16th some of the water, which had not been changed since the beginning of the experiment, was replaced by "outside" water. On October 5th (16 weeks after fertilization) 12 *Echinus* were still alive. Some pieces of red seaweed were placed in the jar, upon which the *Echinus* fixed themselves and fed. Several of these specimens lived for over a year, but sufficient attention was not given to finding suitable food for them after the metamorphosis, so that they did not grow very large.

Echinus esculentus.—Three successful experiments have been made with *E. esculentus.* In the first (eggs fertilized April 5th, 1907) "outside" water treated with animal charcoal and filtered through filter-cloth, but not otherwise sterilized, was used. A number of jars of 2000 c.c. capacity containing larvæ were set up, and, to the most of these, various diatom cultures then in our possession were added, none of which, however, gave a satisfactory result. In two jars, on the

other hand, to which no culture was added, there was considerable growth of diatoms and of a flagellate, upon which the Plutei fed. The first young *Echinus* were recorded in both jars on June 8th (64 days), but may have been present a few days earlier. Eventually from 30 to 40 metamorphosed in one jar and about 12 in the other. The temperature varied from 10·5° C. to 12·5° C.

In the second experiment (eggs fertilized June 8th, 1908), made with similar water, the larvæ were fed on a pure culture of *Nitzschia closterium*, var., and six had completely metamorphosed on July 26th (48 days after fertilization), two more subsequently coming through. The temperature was generally 15° to 16° or 17° C.

In the third experiment (eggs fertilized March 29th, 1909) aquarium tank-water treated with animal charcoal and then filtered through a Berkefeld filter was used. Plutei, fed with a pure culture of a small flagellate (probably *Chilomonas* sp.) grew satisfactorily, and eight young *Echinus* were found on June 5th (68 days after fertilization), which had probably metamorphosed some days earlier. Two other jars in which *Nitzschia closterium*, var., was used as food, were not successful, probably because the growth of diatoms became too thick towards the end of the experiment.

Echinus miliaris. In the first experiment with this species animal-charcoal Berkefeld water was used, each jar containing as usual 2000 c.c. In one jar the Plutei, from eggs fertilized on August 27th, 1907, were fed on a pure culture of *Nitzschia closterium*, var. On October 4th, i.e. thirty-eight days after fertilization, one *Echinus* had just metamorphosed. On October 29th about a dozen healthy-looking *Echini* were climbing about the jar, and many were still in a healthy condition on January 8th, 1908. Temperatures: September, 15° to 19° C., October, 16° dropping to 13° towards end, November, 12° to 11° C., December, 15° to 10° C.

To another jar containing larvæ from the same batch a few drops of fresh Plankton were added as food. The Plutei in this case fed on flagellates and *Nitzschia* which grew in the jar, and several metamorphosed.

In a second experiment with eggs fertilized on September 13th, 1907, the larvæ were fed with *Nitzschia closterium*, but although there were a few well-advanced Plutei still living on January 8th, 1908, none completed the metamorphosis.

Cucumaria saxicola. A female *Cucumaria*, one of a number in a dish containing "outside" water, laid eggs, which were fertilized, and segmented on May 12th, 1906. A number of these were placed in a

flask in 800 c.c. of "outside" water, which had been sterilized by heating and then treated with animal charcoal and filtered. About 1 c.c. of fine plankton, containing diatoms, was added to the flask on May 12th. On May 25th some of the water was poured off and a new supply added. As the amount of food seemed small, some culture of a green alga (*Pleurococcus mucosus* (Kutz.), Rabenh.) was added, and this continued to grow well in the flask. The larvæ continued healthy and formed young *Cucumaria*, of which many were still alive on July 25th, 1907, i.e. fourteen months after fertilization. Some of the water was changed in this flask on May 30th, 1906, June 18th, 1906, September 15th, 1906, and July 25th, 1907. Although many of these *Cucumaria* remained quite healthy they did not grow to any great size. Probably the food which was suitable to the larvæ and early stages, ought to have been changed as the animals grew older.

Pomatoceros triqueter. The larvæ of *Pomatoceros* are perhaps the easiest to rear, and give the most certain results of any with which we have experimented. They do well on the minute variety of *Nitzschia closterium*, but will feed upon almost any small diatom. Since the adults live in calcareous tubes attached to stones, and the tubes have to be broken open before the eggs can be obtained, it is not easy to get the latter free from infection of other organisms. If, therefore, the eggs are fertilized and placed in sterilized animal-charcoal water with only moderate precautions, sufficient growth of diatoms or other organisms will generally take place in the jar to feed the larvæ and bring them to the adult state. When once fixed to the glass the worms are very hardy and healthy, and a stream of ordinary aquarium water can be run through the jar. They then grow rapidly and attain a size equal to any found on the shore. The following experiment may be given in detail to illustrate the time occupied in development. On August 29th, 1907, eggs of *Pomatoceros triqueter* were fertilized in animal-charcoal Berkefeld water, and some pure culture of *Nitzschia closterium*, var., added. The larvæ fed well, and on October 1st (i.e. thirty-three days after fertilization) a great number had fixed on the sides of the jar and made quite normal tubes. A constant stream of the ordinary aquarium water was then allowed to run through the jar, and the worms continued to grow and flourish, reaching a large size, and are still alive and healthy (November, 1909). A similar result was obtained from the same batch of eggs by feeding on a pure culture of a flagellate infusorian. Temperatures during these two experiments were between 15° C. and 19° C.

Chaetopterus variopedatus. Four experiments were made with this

species. The food which gave most promise of success was the diatom *Nitzschia closterium*, var. Larvæ from eggs fertilized on July 20th, 1908, fed on this material lived until October 30th, and reached an advanced stage. They did not, however, adopt the adult habit and form tubes. Two larvæ were also reared to an advanced stage by using flagellates and, in later stages, the diatom *Skeletonema costatum* as food.

Sabellaria alveolata. One experiment only was made with this species on eggs fertilized on July 19th, 1908. The eggs were fertilized in "outside" water and the larvæ subsequently transferred to jars containing animal-charcoal Berkefeld aquarium water. They were fed on a pure culture of *Nitzschia closterium*, var., and kept healthy and active and developed well until nearly the end of October, when, simultaneously with a sudden drop in the temperature from 15° and 16° C. to 12° and 9° C., they sank to the bottom of the vessel and in about three days were all dead. Temperatures:—During July and August, the temperature kept fairly constant at about 17° C., with a range from 15° to 19° C. During September it was generally about 15° C., and continued at about this level until the fall in the middle of October.

Archidoris tuberculata. A good many trials have been made to rear the larvæ of nudibranchiate molluscs, but up to the present not much success has been achieved. The best experiment was one made with larvæ of *Archidoris tuberculata.* A number of veligers of this species hatched out on May 8th, 1908, from some spawn, which had just been collected from the shore. Some of these were put in a flask containing 1000 c.c. of sterilized animal-charcoal water and about 1 c.c. of fine plankton was added. On May 14th a few veligers were transferred to another flask of sterilized animal-charcoal water and some pure culture of the green alga, *Pleurococcus mucosus*, was added. Whereas the larvæ in the original flask did not live long, those provided with the green alga fed well and developed for some time. A number of them were active and vigorous on July 4th, i.e. 51 days after hatching, and several were still swimming at the end of July. On August 15th none could be seen moving, but two of those which lay on the bottom, when examined with the microscope, showed no sign of decomposition. The animal was retracted in the shell, but the tissue looked healthy, and the eye-spots and otoliths could be seen. The growth in the flask seemed to be a quite pure culture of *Pleurococcus.* Larvæ were examined again on September 14th, and appeared much as in August, the tissue still showing no sign of dis-

integration. The flask was not again examined microscopically until July 25th of the following year (1907). No sign of the larvæ could then be seen, but the culture of *Pleurococcus* remained pure and healthy.

Subsequent experiments were made with spawn, which was deposited by the females in confinement. Although the spawn hatched and gave apparently healthy larvæ, these did not live for more than a few days.

Calanus finmarchicus. A single experiment is perhaps worth recording, as showing that it ought to be possible to rear this species without great difficulty. On August 8th, 1905, to a flask containing 1000 c.c. of outside water (unsterilized) there was added $\frac{1}{2}$ c.c. of Miquel's solution B and $\frac{1}{2}$ c.c. of a 1·5 per cent solution of anhydrous sodium carbonate. A few *Calanus finmarchicus* and some decapod Zoeas were put in, together with a quantity of a culture containing mixed diatoms. On September 8th all the Zoeas were dead, but three *Calanus* were alive, and *Nitzschia* and a number of bottom diatoms were very plentiful. On September 17th the three large *Calanus* were alive and vigorous, and a considerable number of *Nauplii* were seen in the flask. By September 22nd two of the *Nauplii* had developed into young *Calanus.* These, however, did not live for more than a week or ten days, and the adults also died. The flask was abandoned on November 13th, the water in it not having been changed since the commencement of the experiment.

Echinus hybrid. A successful experiment on crossing *E. esculentus* and *E. acutus* was carried out by Mr. W. De Morgan, who was working at the Plymouth Laboratory. We provided him with treated water and diatom cultures for food, and he followed our methods. We are indebted to him for allowing us to publish these results. Some eggs from a ripe *E. esculentus* were fertilized by active sperm from *E. acutus* in sterilized water on March 29th, 1909. Healthy larvæ were obtained and were transferred two days later to tank-water, which had been treated with animal charcoal and filtered through a Berkefeld filter. A culture of *Nitzschia closterium*, var., was added as food, and the larvæ developed rapidly, feeding well. Several were completely metamorphosed on May 7th, or thirty-nine days after fertilization. In all thirty young hybrids were obtained, and a number of these are still alive and feeding on red weeds.

Sacculina carcini. Mr. Geoffrey Smith has recorded the fact (*Quart. Journ. Micr. Sci.*, LI, 1907, p. 625) that he was able to rear the larvæ of *Sacculina* up to the Cypris stage, when they attached themselves to

their host, *Carcinus maenas*. These larvæ were kept in aquarium tank-water treated with animal charcoal and filtered through a Berkefeld filter. In this case the question of food did not arise, as the larvæ do not feed after hatching. It must be noted, however, that these larvæ had previously been reared by Müller and by Delage.

Summary of Method for Rearing Larvæ. We have found that the best results in rearing marine larvæ have been attained by taking the following precautions:—

1. The eggs of the female selected must be really ripe, and the spermatozoa of the male active.
2. The smallest quantity of sperm necessary to fertilize the eggs should be used.
3. Sterile sea-water, treated in such a way that diatoms, etc., will grow well in it, should be used. No frequent change of water is then necessary.
4. All dishes, jars, instruments, and pipettes should be carefully sterilized before use. Every possible effort should be made to prevent the introduction into the rearing-jars of any organisms other than the larvæ to be reared, and organisms on which they feed. The jars should be covered with loosely fitting glass covers.
5. The eggs after fertilization must be separated from all foreign matter, pieces of ovary, or testis, etc. As soon as the larvæ swim up they should be pipetted off into fresh vessels of treated water, so as to leave behind any unsegmented eggs, etc.
6. The food organisms should be small in size, so that the larvæ can draw them into the mouth by ciliary currents. The food should distribute itself through the body of the liquid and not settle too readily on the bottom of the vessel. (This is one of the great advantages of the diatom *Nitzschia closterium, forma minutissima*.)
7. The food should be abundant early, so that the larvæ may commence feeding as soon as they are able to do so. The food, however, must not be allowed to get excessively thick in the water. It can be kept down by diminishing the light .or by changing some of the water.
8. The temperature should be kept as constant as possible. Within limits, the actual degree of temperature is not so important as the avoidance of rapid change of temperature.
9. A good north light, not exposed to direct sunlight, is most suitable for the rearing-jars.

10. In determining the amount of water to be used in any particular vessel, regard must be had to the amount of water surface exposed to the air, which should be large in proportion to the volume of the water.
11. A change of food is generally required after the metamorphosis of the larvæ.

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On the Species Upogebia stellata and Gebia deltura.

By

W. De Morgan, F.Z.S.

As remarked by Stebbing (*A History of Recent Crustacea*, p. 185): "Upogebia, Leach, 1814, was founded to receive another species discovered by the industrious Montagu, and described by him in 1805 (1808) as *Cancer astacus stellatus*. . . . It seems to have escaped the notice of writers subsequent to Leach that the earliest name of this genus was Upogebia, which therefore must be retained in preference to Leach's own alteration of it into Gebia, or Risso's Gebios."

Some doubt still appears to exist whether *Upogebia stellata* (Leach) and *Gebia deltura* (Leach) are distinct, or merely sexual forms of the same species.

Leach gives excellent figures of *Gebia stellata* (*Malac. Podolph. Brit.*, table xxi, figs. 1–9) and *Gebia deltura* (figs. 9–10). He regarded them as distinct species, and remarks of *Gebia deltura*: "This species lives with *Gebia stellata*, with which it was confounded, until the distinctions were discovered by Mr. J. D. C. Sowerby." I am unable to find out whether Mr. Sowerby recorded his description.

Bell (*British Stalk-eyed Crustacea*, pp. 223–5) describes *Gebia stellata* and *Gebia deltura* under the genus Gebia (Leach), of the Thalassinidæ, and gives good figures of both. He appears to doubt, however, whether they are distinct species, and of *G. deltura* writes: "This species, if it be indeed distinct, differs from the former, *G. stellata*, in the following particulars: the whole animal is very much larger, sometimes not less than twice the length, and more than proportionately wider. The carapace is much broader and more spreading at the sides. The legs are more robust; the arm of the first pair is not more than twice as long as it is broad, the wrist even shorter than broad, the hand thicker, and the fingers more nearly of equal length. The setæ of the external antennæ are shorter in proportion, being, according to Leach's figure, not more than half the length of the body. The abdomen is broader, more spread, and much less firm in its texture, the sides being almost membranaceous, and the abdominal false feet larger and more voluminous than in the other species. The different lamellæ of the

tail differ also in some particulars, the exterior being rather broader than it is long, and the middle one, or terminal segment, of the abdomen nearly quadrate. In all other respects the two species very greatly resemble each other."

In a note Bell remarks: "The term 'deltoid' appears to be very much misplaced in describing this part."

If Leach referred to the central lamella of the tail, the term is misleading, as that plate is certainly subquadrate in form. But, as pointed out by Stebbing (*History of Crustacea*, p. 186), Leach was no doubt referring to the minor branch of the Uropods, which may reasonably be described as "deltoid."

Bell further remarks: "I confess I am very doubtful if it will not prove on further investigation that the two British forms, and perhaps also *G. littoralis* of Risso, constitute but one species. The form and development of the abdomen, and the great development of the abdominal false feet in *G. deltura*, are certainly very much like peculiarities belonging to the female sex, and calculated for the support and protection of the ova."

Norman appears to consider that there is only one species. In his *Crustacea of Devon and Cornwall*, p. 12, he has:—

"*Upogebia stellata* (Montagu) = *Gebia deltura* (Leach)."

At the Marine Biological Laboratory, Plymouth, I have had the opportunity of examining a good many specimens of both forms, both alive and in spirit. The two forms are always found together at Salcombe, and a day's hunting may produce a dozen specimens. *Stellata* is rather more common than *deltura*.

I have kept several of the *stellata* form in berry under circulation, and the zoœas have hatched out, and one specimen of the *deltura* form, in berry, which also hatched. In neither case, however, was I able to rear the larvæ. There are thus males and females of both forms. The genital opening of both forms is situated in the females on the basipodite of the 3rd thoracic appendage, and is covered by a diaphragm. It is very easy to see. In the males, the opening is on the basipodite of the 5th thoracic segment. Close to it, there is a small tuft of setæ. It is not so easy to distinguish as in the female.

The females of both forms possess modified copulatory appendages, and may be recognised by them, as they are absent in the males.

Among the Thalassinidæ, Upogebia forms a rare exception to the general rule on this point (*vide* Calman, in *Treatise of Zoology*, ed. by Ray Lankester, part vii, p. 274).

In large specimens it is easy to distinguish between *deltura* and *stellata*. The width of the abdominal plates in *deltura* is very noticeable, and the rostrum is blunter. It is altogether a more massive animal, and the spotted appearance, whence the name *stellata*,

FIG. 1.—Upogebia stellata, showing spine.
Cam. luc. × 27.

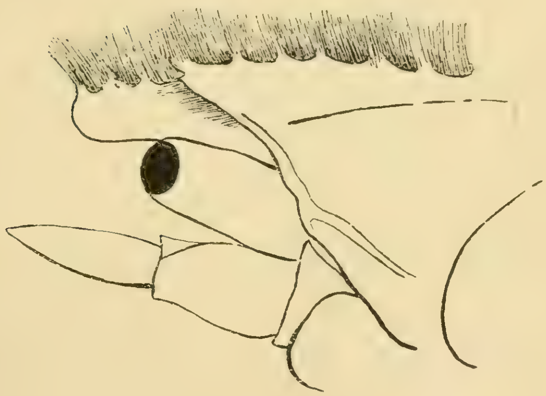

FIG. 2.—Gebia deltura.
Cam. luc. × 27.

is wanting. In *deltura* the dactylopod is stouter and blunter, and more nearly equals the process of the propodite in length. On the inner side, where the dactylopod hinges, there are two blunt spines. In *stellata* the "fingers" are much slighter, the dactylopod longer and slenderer, and the opposite process smaller, than in *deltura*.

The hairs on the rostrum and carapace, and also on the edges of the abdominal plates, are longer and thicker in *deltura* than in *stellata*, and give it a more shaggy appearance.

In small specimens, however, these differences are not so marked. But *stellata* has one mark which always distinguishes it from *deltura*, namely, a small spine on the curved edge of the frontal margin of the carapace behind the eye-stalks. In ordinary specimens it is easily seen; in very small ones a lens may be required to detect it, but its presence in *stellata* is constant. In *deltura* it is absent, and the margin of the carapace forms an unbroken curve. The spine is shown in the figure (*cf.* Figs. 1 and 2).

This spine is not shown in the figures of either Leach or Bell. It would hardly be visible on so small a scale; also, it would hardly be seen in the position in which the animal is drawn. From the above considerations it appears that *Upogebia stellata* and *Gebia deltura* are clearly distinct species.

Marine Biological Association of the United Kingdom.

Report of the Council, 1908-9.

The Council and Officers.

Four ordinary meetings and one special meeting of the Council have been held during the year, at which the average attendance has been ten.

The Laboratories at Plymouth and Lowestoft have both been visited by Committees of the Council.

The thanks of the Council are due to the Councils of the Royal Society and of the Linnean Society for the use of their rooms for the meetings.

The Council have been requested by H.M. Government to continue the work which they have been doing in connection with the International Fishery Investigations for a further year.

The Laboratories.

No large repairs have been necessary to the buildings and machinery at Plymouth. The new centrifugal pump has continued to give satisfactory results, and the self-sown invertebrate fauna in the tanks of the aquarium has been larger than usual. At Lowestoft, arrangements have been made with the landlord of the house occupied by the Association to continue the tenancy for a further year.

The Boats.

The steam-trawler *Huxley* has carried out the international work in the North Sea and English Channel. She was laid up at Plymouth for three months during the winter.

The *Oithona* has worked at Plymouth during the summer months, the collecting in the winter being done, as in previous years, by the sailing-boat *Anton Dohrn*.

The Staff.

Mr. R. A. Todd and Dr. W. Wallace have been promoted to the rank of Naturalist, whilst Mr. G. T. Atkinson and Mr. H. J. B.

Wollaston have been appointed Assistant Naturalists. The staff is now composed as follows :—

Director—E. J. ALLEN, D.SC.

PLYMOUTH LABORATORY.

Assistant Director—L. R. CRAWSHAY, M.A.
Hydrographer (*International Investigations*)—D. J. MATTHEWS.
Assistant Naturalists—A. E. HEFFORD, B.SC., E. W. NELSON.
Assistant Naturalist (*International Investigations*)—A. J. MASON-JONES, M.SC.

LOWESTOFT LABORATORY (*International Investigations*).

Assistant Director—J. O. BORLEY, M.A.
Naturalists—W. WALLACE, D.SC. R. A. TODD, B.SC.
Statistical Assistant—Miss R. M. LEE, M.A.
Assistant Naturalists—G. T. ATKINSON. H. J. BUCHANAN WOLLASTON.

Occupation of Tables.

The following Naturalists have occupied tables at the Plymouth Laboratory during the year :—

Miss BAINBRIDGE, London (Fish Parasites).
Miss BAMFORD, Cambridge (General Zoology).
F. J. BRIDGMAN, London (Sponges).
A. F. COVENTRY, Oxford (Cell Lineage).
W. C. DE MORGAN, Plymouth (Crustacea and Echinoderms).
E. R. DOWNING, PH.D., Marquette, Michigan (Arenicola).
G. H. DREW, Plymouth (Pathology of Fishes).
Sir CHARLES ELIOT, K.C.M.G., Sheffield (Nudibranchs).
T. J. EVANS, M.A., Sheffield (General Zoology).
F. W. GAMBLE, F.R.S., Manchester (Colour Physiology of Crustacea and Fishes).
T. GOODEY, B.SC., Birmingham (Aurelia).
F. H. GRAVELY, M.SC., Manchester (Polychæte Larvæ).
G. H. GROSVENOR, M.A., Oxford (Actinia).
Miss A. ISGROVE, M.SC., Manchester (Mollusca).
J. W. JENKINSON, M.A., Oxford (Embryology).
W. O. R. KING, Cambridge (Polychætes).
C. H. MARTIN, B.A., Glasgow (Protozoa).
J. PEARSON, D.SC., Liverpool (Cancer).
F. A. POTTS, B.A., Cambridge (Maldanidae).
C. SHEARER, M.A., Cambridge (Histriobdella).
Rev. J. H. SCALES, London (General Zoology).
Rev. G. WADDINGTON, London (General Zoology).
R. WHITEHOUSE, B.SC., Birmingham (Fishes).
H. J. B. WOLLASTON, Lowestoft (Fishes).
W. WOODLAND, D.SC., London (Gobius).

In addition to the above, twenty-four students attended the Laboratory during the Easter vacation, when Mr. G. H. Grosvenor conducted the usual course of instruction in Marine Biology.

The Library.

The thanks of the Association are due for the following books and current numbers of periodicals presented to the Library during the past year:—

Académie Imp. des Sciences de St. Pétersbourg. Bulletin.
American Museum of Natural History. Bulletin.
—— Report.
American Microscopical Society. Transactions.
American Philosophical Society. Proceedings.
Armstrong College. Calendar.
Australian Museum. Records.
—— Report.
Bergens Museum. Aarbog.
—— An Account of the Crustacea of Norway, etc.; by G. O. Sars.
Bernice Pauahi Bishop Museum, Honolulu. Occasional Papers.
—— Fauna Hawaiiensis.
—— Memoirs.
Board of Agriculture and Fisheries. Annual Report of Proceedings under the Salmon and Freshwater Fisheries Acts.
—— Annual Report of Proceedings under Acts relating to Sea Fisheries.
—— Report of Proceedings of Annual Meeting.
—— Return of the Number of Steam Trawlers Registered at Ports in the States of Western Europe in 1907.
—— Report on the Research Work of the Board in relation to the Plaice Fisheries of the North Sea.
Boston Society of Natural History. Proceedings.
Bristol Naturalists Society. Proceedings.
British Association for the Advancement of Science. Report.
British Museum. National Antarctic Expedition, 1901–4. Natural History.
—— Guide to the Gallery of Fishes in the Department of Zoology.
Brooklyn Institute of Arts and Sciences. Cold Spring Harbor Monographs.
—— Science Bulletin.
Bryn Mawr College. Monographs, Reprint Series.
Bulletin Scientifique de la France et de la Belgique.
Cairo Zoological Gardens. Report.
—— Special Report.
California Academy of Sciences. Proceedings.
College of Science, Tokyo. Journal.
College voor de Zeevisscherijen. Verslag van den Staat der Nederlandsche Zeevisscherijen.
Colombo Museum. Spolia Zeylanica.
Conchological Society of Great Britain and Ireland. Journal of Conchology.
Conseil perm. internat. pour l'Exploration de la Mer. Bulletin Trimestriel des Résultats acquis pendant les Croisières Périodiques.
—— Bulletin Statistique.
—— Publications de Circonstance.
—— Rapports et Procès-Verbaux des Réunions.
Cuerpo de Ingenieros de Minas del Peru. Boletin.
Danish Biological Station. Report to the Board of Agriculture.

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—— Skrifter.
Dept. of Agriculture, etc., Ireland. Reports.
—— Scientific Investigations.
—— The Department's Fishery Cruiser *Helga.*
Dept. of Commerce and Labor, U.S.A. Pamphlets.
—— Report of the Commissioner of Fisheries.
Dept. of Fisheries, New South Wales. Annual Report.
—— Edible Fishes of New South Wales. By D. G. Stead.
—— New Fishes from New South Wales. By D. G. Stead.
—— The Beaked Salmon (*Gonorhynchus gonorhynchus*, Linnaeus). By D. G. Stead.
Dept. of Marine and Fisheries, Canada. Annual Report.
—— Supplement to the 32nd Annual Report.
—— Georgian Bay Fisheries Commission, 1905–8. Report and Recommendations.
—— Dominion British Columbia Fisheries Commission, 1905–7. Report and Recommendations.
Deutsche Zoologische Gesellschaft. Verhandlungen.
Deutcher Fischerei Verein. Zeitschrift für Fischerei.
Deutscher Seefischerei Verein. Mitteilungen.
Dominion Museum, New Zealand. Bulletin.
Falmouth Observatory. Meteorological and Magnetic Reports.
La Feuille des Jeunes Naturalistes.
Field Museum of Natural History. Annual Report.
—— Publications.
Finnlandische Hydrographisch-Biologische Untersuchungen.
Fisheries Society of Japan. Journal.
The Fisherman's Nautical Almanac ; by O. T. Olsen.
Fishery Board of Scotland. Annual Report.
Fiskeri-Beretning, 1907–8.
Government Museum, Madras, Report.
Illinois State Laboratory of Natural History. Bulletin.
Imperial University, Tokyo. Calendar.
Indian Museum. Illustrations of the Zoology of R.I.M.S. Ship *Investigator.*
Institut de Zoologie, Montpellier. Travaux.
Internationale Meeresforschung. Jahresbericht.
R. Irish Academy. Proceedings.
Kansas University. Science Bulletin.
Kommission zur wissenschaftlichen Untersuchung der Deutschen Meere, etc. Wissenschaftliche Meeresuntersuchungen.
Kommissionen for Havundersögelser, Copenhagen. Meddelelser, series Fiskeri, Hydrografi, Plankton.
—— Skrifter.
Kgl. Norske Videnskabernes Selskab. Skrifter.
Laboratoire Biologique de St. Pétersbourg. Bulletin.
Lancashire Sea Fisheries Laboratory. Report.
Lancashire and Western Sea Fisheries. Superintendent's Report.
Leland Stanford Junior University. Publications.
Linnean Society, N. S. Wales. Proceedings.
Liverpool Biological Society. Proceedings and Transactions.

Liverpool Marine Biology Committee. Marine Biological Station at Port Erin. Report.

Manchester Microscopical Society. Annual Report and Transactions.

Marine Biological Association of the West of Scotland. Report.

Marine Biological Laboratory, Woods Holl. Biological Bulletin.

Mededeelingen over Visscherij.

Meteorological Office. Monthly Pilot Charts, North Atlantic and Mediterranean.

—— Monthly Pilot Charts, Indian Ocean and Red Sea.

—— Annual Report of the Committee.

R. Microscopical Society. Journal.

Ministère de l'Instruction Publique, France. Nouvelles Archives des Missions Scientifiques.

Ministère de la Marine, France. Travaux du Service Scientific des Pêches Maritimes en 1906.

Musée Oceanographique de Monaco. Bulletin.

Museo de La Plata. Anales.

—— Revista.

Museo Nacional, Buenos Aires. Anales.

Museum of Comparative Zoology, Harvard College. Bulletin.

—— Memoirs.

—— Report.

Muséum National d'Histoire Naturelle, Paris. Bulletin.

—— Nouvelles Archives.

The Museums Journal.

Naturforschende Gessellschaft in Basel. Verhandlungen.

Naturhistorischen Museum, Hamburg. Mitteilungen.

Neapel. Mitteilungen aus der Zoologischen Station.

Nederlandsche Dierkundige Vereeniging. Verslag.

—— Tijdschrift.

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New Zealand Institute. Transactions and Proceedings.

Nikolsk : l'Etablissement de Pisciculture.

Iz Nikol 'skagho R'ibovodnagho Zavoda.

Norges Fiskeristyrelse. Aarsberetning vedkommende Norges Fiskerier.

Northumberland Sea Fisheries Committee. Report on Scientific Investigations.

La Nuova Notarisia.

Oberlin College. The Wilson Bulletin.

Otago Acclimatisation Society. Report.

—— Work of Acclimatisation ; by R. Chisholm.

Owens College, Manchester. On a new Phytophagous Mite, *Lohmannia insignis*, Berl. var. *dissimilis* n. var., with notes on other species of economic importance ; by C. G. Hewitt.

—— The Physical Basis of Hereditary Characters ; by S. J. Hickson.

—— On the systematic position of *Eunephthya maldivensis*, Hickson ; by S. J. Hickson.

—— The Percy Sladen Trust Expedition to the Indian Ocean in 1905, XIX. The Stylasterina of the Indian Ocean ; by S. J. Hickson and H. M. England.

—— On the Structure of *Dendrosoma radians ;* by S. J. Hickson and J. T. Wadsworth.

Oxford University Museum. Catalogue of Books added to the Radcliffe Library.

Physiographiske Forening. Christiania. Nyt Magazin for Naturvidenskaberne.

Plymouth Museum and Art Gallery. Annual Report.

Quarterly Journal of Microscopical Science. (Presented by Sir E. Ray Lankester, K.C.B., F.R.S.)

Queensland Museum. Annals.

Rijksinstituut voor het Onderzoek der Zee. Helder. Jaarboek.

—— Verhandelingen.

—— Vangstatistieken van Hollandsche Stoomtrawlers.

Royal Society of Edinburgh. Proceedings.

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—— Proceedings.

—— National Antarctic Expedition, 1901–04. Physical Observations. Meteorology. Album of Photographs and Sketches.

—— Reports of the Evolution Committee.

—— Year-Book.

Royal Society of Victoria. Proceedings.

Selskabet for de Norske Fiskeriers Fremme. Norsk Fiskeritidende.

Senckenbergische naturforschende Gesellschaft, Frankfurt. Bericht.

Smithsonian Institution. A Further Report on the Ostracoda of the U.S. National Museum; by R. W. Sharpe.

—— North American Parasitic Copepods: A List of those found upon the Fishes of the Pacific Coast, with descriptions of new genera and species; by C. B. Wilson.

—— The Isopod Crustacean, *Ancinus depressus* (Say.); by H. Richardson.

—— Comatilia, a Remarkable New Genus of Unstalked Crinoids; by A. H. Clark.

—— Four New Species of Isopods from the Coast of California; by S. J. Holmes and M. E. Gay.

—— Some New Isopods of the Family Gnathiidae from the Atlantic Coast of North America; by H. Richardson.

—— The Amphipoda collected by the U.S. Bureau of Fisheries' Steamer *Albatross* off the West Coast of North America, in 1903 and 1904, with descriptions of a new family and several new genera and species; by S. J. Holmes.

—— The American Species of Snapping Shrimps of the Genus Synalpheus; by H. Coutière.

—— Alcyonaria of the Californian Coast; by C. C. Nutting.

Sociedad Scientifica de São Paulo. Revista.

Société Belge de Géologie, etc. Bulletin.

—— Nouvelle Mémoires.

Société Centrale d'Aquiculture et de Pêche. Bulletin.

Société d'Océanographie du Golfe de Gascogne. Rapports.

Société Suisse de Pêche et Pisciculture. Bulletin.

Société Imp. Russe de Pisciculture et de Pêche. Vyestnīk R'ibopom'shlennostī.

Société Zoologique de France. Bulletin.

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South African Central Locust Bureau. Report.

South African Museum. Annals.

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Station de Pisciculture et d'Hydrobiologie, Toulouse. Bulletin Populaire.
Station de Recherches Maritimes, Ostende. Travaux.
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Kgl. Svenska Vetenskaps-Akademien. Arkiv för Botanik.
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R. Universita di Napoli, Museo Zoologico. Annuario.
—— Centenario della Cattedra di Zoologia nella R. Universita di Napoli, 1806–1906.
University of California. Publications. Zoology, Physiology, Botany.
University of Pennsylvania. University Bulletins.
—— Catalogue.
—— Contributions from the Botanical Laboratory.
—— Proceedings of "University Day."
—— Provost's Report.
University of Toronto. Studies.
Kgl. Vetenskaps Societeten, Upsala. Nova Acta.
Visschershaven, Ijmuiden. Jaarsverslag.
Zoological Society of Japan. Annotationes Zoologicæ Japonenses.
Zoological Society of London. Proceedings.
—— Transactions.
Zoological Museum, Copenhagen. The Danish Ingolf-Expedition.
Zoologischen Museum, Berlin. Bericht.
—— Mitteilungen.

Anon. Bericht über die von Herrn Dr. Döderlein in Japan gesammelten Pycnogoniden; by A. Ortmann.
—— Uebersicht der von P. Schmidt und W. Braschnikow in den Ostasiatischen Ufergewässern gesammelten Pantopoden; by W. Schimkewitsch.
—— Zur Pantopoden-fauna des Sibirischen Eismeeres.
Mr. E. T. Browne. Über die Nesselkapseln von Hydra; by H. Grenacher.
—— Zur Frage über die Keimblatterbildung bei den Hydromedusen; by W. Gerd.
—— Über die Entwicklung der Aurelia aurita und der Colylorhiza borbonica; by A. Goette.
—— Note on Selaginopsis (=*Polycerias Hincksii*, Mereschkowsky), and on the Circumpolar Distribution of certain Hydrozoa; by A. M. Norman.
—— Om Forngelsen af Ernaeringsindividerne hos Hydroiderne; by G. M. R. Levinsen.
—— Über eine neue Form des Generations-wechsels bei den Medusen und über die Verwandtschaft der Geryoniden und Aeginiden; by E. Haeckel.
—— Preliminary Report of the Biological Results of a Cruise in H.M.S. *Valorous* to Davis Strait in 1875; by J. Gwyn Jeffreys.

Mr. E. T. Browne. Report on the Physical Investigations carried on by P. Herbert Carpenter in H.M.S. *Valorous* during her return voyage from Disco Island in August, 1875; by W. B. Carpenter.

—— Review on "Das System der Medusen" von Dr. Ernst Haeckel; by A. Agassiz.

—— Ueber Tastapparate bei *Eucharis multicornis*; by Th. Eimer.

—— Histoire Naturelle des Polypes composés d'Eau douce; by Dumortier and Van Beneden.

—— Poriferen, Anthozoën, Ctenophoren und Würmer von Jan Mayen; by E. von Marenzeller.

—— Auszug aus den Beobachtungen über die Siphonophoren von Neapel und Messina angestellt im Winter 1859–60; by W. Keferstein and E. Ehlers.

—— De Zoophytorum et historia et dignitate systematica; by R. Leuckart.

Dr. G. H. Fowler. Biscayan Plankton collected during a cruise of H.M.S. *Research* in 1900. VIII–X.

Dr. H. R. Mill. Symons's Meteorological Magazine.

Mr. E. W. Nelson. Microscopy; by E. J. Spitta.

Dr. A. E. Shipley. On the Fauna of the Bradford Coke Bed Effluent; by Dr. A. Meixner.

To the authors of the Memoirs mentioned below the thanks of the Association are due for separate copies of their works presented to the Library:—

Ameghino, F. Le Litige des Scories et des Terres Cuites Anthropiques des Formations néogènes de la République Argentine.

Bainbridge, M. E. Notes on some Parasitic Copepoda; with a description of a new species of Chondracanthus.

Church, A. H. The Polymorphy of *Cutleria multifida* (Grev.).

Cligny, A. Sur un nouveau genre de Zeidés.

—— Deux Clupeides a supprimer de la Nomenclature *Harengula latulus*, C. et V., et *Meletta phalerica* (Risso).

Cole, G. W. Bermuda in Periodical Literature.

Cooper, W. F., and Robinson, L. E. On six new species of Ixodidae, including a second species of the new Genus Rhipicentor, N. and W.

Cotton, A. D. *Leathesia crispa*, Harv.

Dakin, W. J. The Osmotic Concentration of the Blood of Fishes taken from Sea-water of Naturally Varying Concentration.

—— Methods of Plankton Research.

—— Notes on the Alimentary Canal and food of the Copepoda.

Darbishire, A. D. On the Result of Crossing Round with Wrinkled Peas, with Especial Reference to their Starch-grains.

—— An Experimental Estimation of the Theory of Ancestral Contributions in Heredity.

—— Some Tables for illustrating Statistical Correlation.

Davenport, C. B. Determination of Dominance in Mendelian Inheritance.

—— Heredity and Mendel's Law.

—— Inheritance in Canaries.

—— Co-operation in Science.

Davenport, G. C., and Davenport, C. B. Heredity of Eye-colour in Man.

—— Heredity of Hair-form in Man.

Dorée, C. The Occurrence and Distribution of Cholesterol and allied bodies in the Animal Kingdom.

Driesch, Hans. Zwei Mitteilungen zur Restitution der Tubularia.

—— Zur Theorie der Organischen Symmetrie.

—— Über eine fundamentale Klasse morphogenetischer Regulationen.

Eliot, C. On the Genus Cumanotus.

—— Reports on the Marine Biology of the Soudanese Red Sea, XI. Notes on a Collection of Nudibranchs from the Red Sea.

Elmhirst, R. Notes on Nudibranchiate Molluscs.

Foster, E. Notes on the Free-swimming Copepods of the waters in the vicinity of the Gulf Biologic Station, Louisiana.

Goodey, T. On the presence of Gonadial Grooves in a Medusa, *Aurelia aurita.*

Gough, L. H. Notes on South African Parasites.

Harmer, S. F. Address to the Zoological Section. [British Association.]

Harrison, R. G. Regeneration of Peripheral Nerves.

Herdman, W. A. Address delivered at the Anniversary Meeting of the Linnean Society, May 24th, 1908.

Hjort, J. Review of Norwegian Fishery and Marine Investigations.

Hoffbauer, C. Weitere Beiträge zur Alters-und Wachstumsbestimmung der Fische, spez. des Karpfens.

Horst, R. On the Supposed Identity of *Nereis* (*Neanthes*) *succinea*, Leuck., and *N. perrieri*, St. Jos.

—— On a Bhawania specimen. A Contribution to our Knowledge of the Chrysopetalidæ.

Janet, C. Histolyse, sans phagocytose, des muscles vibrateurs du vol, chez les reines des Fourmis.

—— Histogénèse du tissu adipeux remplaçant les muscles vibrateurs histolysés après le vol nuptial, chez les reines des Fourmis.

—— Histolyse des muscles de mise en place des ailes, après le vol nuptial, chez les reines de Fourmis.

—— Anatomie du corselet et histolyse des muscles vibrateurs, après le vol nuptial, chez la reine de la Fourmi (Lasius niger).

M'Intosh, W. C. Notes from the Gatty Marine Laboratory.

Man, J. G. de. Description of a new species of the genus *Sesarma*, Say., from the Andaman Islands.

—— On *Caridina nilotica* (Roux) and its varieties.

—— Decapod Crustacea, with an Account of a small collection from Brackish Water near Calcutta and in the Dacca District, Eastern Bengal.

Martin, C. H. Notes on some Oligochaets found on the Scottish Loch Survey.

—— Notes on some Turbellaria from Scottish Lochs.

—— The Nematocysts of Turbellaria.

—— *Weldonia parayguensis*, a doubtful form from the fresh water of Paraguay.

Montgomery, T. H. On the Morphology of the Excretory Organs of Metazoa; A Critical Review.

Moore, J. P. Descriptions of New Species of Spioniform Annelids.

—— Description of a New Species of Annelid from Woods Hole.

—— Some Polychaetous Annelids of the Northern Pacific Coast of North America.

Norman, A. M. The Podosomata (=Pycnogonida) of the Temperate Atlantic and Arctic Oceans.

Nuttall, G. H. F., Cooper, W. F., and Robinson, L. E. On the Structure of "Hallers Organ" in the Ixodoidea.

—— On the Structure of the Spiracles of a Tick—"Haemaphysalis punctata," Canestrini and Fanzago.

Pfeffer, G. Teuthologische Bemerkungen.

Prince, E. E. Presidental Address [Royal Society of Canada]. The Biological Investigation of Canadian Waters, with Special Reference to the Government Biological Stations.

Pütter, A. Die Ernährung der Fische.

Sauvageau, C. Le Professeur David Carazzi de l'Université de Padoue (Italie), les Huitres de Marennes et la Diatomée Bleue.

Schaeberle, J. M. On the Origin and Age of the Sedimentary Rocks.

Sedgwick, A. A Student's Text-Book of Zoology. Vol. III.

Shipley, A. E. Interim Report on the Parasites of Grouse.

—— Note on *Cystidicola farionis*, Fischer. A Threadworm parasitic in the swim-bladder of a Trout.

—— Note on the Occurrence of *Triaenophorus nodulosus*, Rud., in the Norfolk Broads.

—— A Cause of Appendicitis and other Intestinal Lesions in Man and other Vertebrates.

Sumner, F. B. The Biological Laboratory of the Bureau of Fisheries at Woods Hole, Mass. Report of Work for the Season of 1907.

Tattersall, W. M. Two new Mysidae from Brackish Water in the Ganges Delta.

Trybom, F. Die im Jahre 1906 ausgeführten schwedischen Untersuchungen mit markierten Plattfischen in der Ostsee.

—— Nachtrag zum Bericht über die mit Schollen und Hummern an der Westküste Schwedens ausgeführten Markierungen.

Vincent, S., and Thompson, F. D. The Islets of Langerhans and the Zymogenous Tubules in the Vertebrate Pancreas, with special reference to the Pancreas of the Lower Vertebrates.

Walker, A. O. Amphipoda Gammaridea from the Indian Ocean, British East Africa, and the Red Sea.

Woodruff, L. L. Effects of Alcohol on the Life Cycle of Infusoria.

—— The Life Cycle of Paramecium when subjected to a Varied Environment.

General Work at the Plymouth Laboratory.

A report by Mr. L. R. Crawshay has been published in the Journal of the Association (Vol. VIII, Pt. 3) on an experiment in the keeping of Salmon in sea-water at the Plymouth Laboratory, which was carried out for the Duke of Bedford. Salmon smolts, which were two years old when first transferred to sea-water in February, 1906, showed signs of maturity in November of the same year. They were then transferred to fresh water, and produced fertile ova. In March, 1907, the fish were returned to sea-water, and they were again returned to fresh water, and spawned in the autumn of that year.

The smolts in the above experiment had been reared artificially in the hatchery at Endsleigh. A similar experiment is now being carried on with wild smolts.

Two reports on the Western Mackerel Fishery have been published

in the Journal. One, by Mr. G. E. Bullen, deals with the food of the mackerel, and suggests a correlation between the abundance of mackerel on the fishing grounds off the Cornish coast in May, and the amount of Copepod plankton, upon which the fish feed, present in the water at the time. The second paper, by Dr. Allen, attempts to carry the question a step further, and shows some evidence for thinking that the abundance of mackerel in May varies with the amount of sunshine in the earlier months of the year (February and March). It is suggested that the amount of sunshine influences the growth of diatoms and other plant life, which in its turn influences the Copepod plankton upon which the mackerel feed.

Mr. E. W. Nelson has again been engaged, in association with Dr. Allen, in experiments on the cultivation of marine plankton diatoms and the rearing of pelagic larvæ. A report on this work is now in preparation.

Mr. A. E. Hefford has been occupied in studying the reproduction of teleostean fishes in the neighbourhood of Plymouth by means of observations of the gonads of mature fishes, and of the eggs and larvæ taken in tow-nettings, and in a modified form of the Petersen young-fish trawl.

Records have been kept of the pelagic eggs collected at regular intervals during the early months of the present year. The eggs, with few exceptions, were kept alive in the Laboratory, and observations were made on the developing embryos and the early larval stages. An outstanding feature of the investigation is the preponderance in abundance, though not in number of species, of the eggs of unmarketable fishes over those of marketable forms, those of *Motella* and of *Callionymus lyra* being particularly abundant and of continuous occurrence.

The commencement of spawning for most of the species observed appears to have been earlier this year than usual.

The International Fishery Investigations.

The following is a summary of the work done, and of the conclusions arrived at by the scientific staff working under the direction of the Council.

Section I—NORTH SEA WORK.

A. WORK OF THE S.S. "HUXLEY."

From June 1st, 1908, to the end of May, 1909, the *Huxley* made nine voyages, in the course of which 193 hauls of the commercial trawl were made, together with 116 hauls of various smaller nets and gear. The total number of voyages made by the *Huxley* from the commence-

ment of the investigations to the present time is 108; the total number of hauls made with commercial trawls is 1447, that with smaller gear, 1269.

TRAWLING INVESTIGATIONS.—The investigation of fixed stations and fixed lines, which was carried out in the spring of 1908, was repeated in June and August of that year, the gear used being the same as on the first occasion. Trawling also took place along the East Anglian coast, and in The Wash, for the collection of soles; and on the Dutch, Danish, and English coasts, in order to obtain plaice for Vitality Experiments and for Transplantation. The Association is indebted to the Eastern Sea Fisheries District Committee, and to Mr. H Donnison, their Inspector, for assistance rendered by the *Protector* in connection with the first of these operations. The *Huxley* also obtained eight boxes of plaice from Teignmouth Bay, for the purpose of otolith investigation.

DREDGING INVESTIGATIONS.—Various descriptions of small gear were used both at the fixed stations and elsewhere. During the year 39 samples of the sea bottom were added to the collection already made.

FISH MEASURED.—Over 107,000 fish were measured at sea during the year. As in past years, the entire catch was measured on nearly all occasions. The details as to the number of plaice, haddock, and other species dealt with are as follows:—

YEAR.	PLAICE.	HADDOCK.	OTHERS.	TOTALS.
1902–8* ...	139,964	48,513	295,247 ...	483,724
1908–9 ...	34,821	1,810	71,153 ...	107,784
Totals	174,785	50,323	366,400 ...	591,508

During the past winter the measurements and maturity examination of plaice have been continued on the smacks and fish-market at Lowestoft. From the end of October, 1908, to the close of March, 1909, over 17,000 plaice from the south part of the North Sea have been dealt with.

MARKING EXPERIMENTS.—From the commencement of the investigations 15,887 plaice, together with 713 soles and 552 other fish, have now been marked and liberated by the Association. Of these, 3515 plaice, 51 soles, and 110 other fish have been recovered.

During the year 1908–9, 1385 marked plaice were liberated approximately at the position at which they were captured. The majority of these were marked in the southern extremity of the North Sea, in March, with a view to casting further light on the movements

* Excluding certain small fish caught in small gear in 1907.

of the large spent fish which are then leaving this portion of the sea. It is intended to conduct similar experiments in January, 1910, as the plaice whose movements it is desired to study can usually be obtained in greater numbers earlier in the year.

Over three thousand fish also were taken in the North Sea and transplanted to other grounds. Of these, 2550 were transplanted to the Dogger Bank, having been procured in about equal numbers on the English, Dutch, and Danish coasts. Plaice taken to the Dogger Bank from the Dutch and Danish coasts in May, 1908, were found, on recapture in December last, to have differed somewhat in their rate of growth. It was accordingly considered advisable to secure comparable data as to the growth rate, on the Dogger Bank, of plaice brought from different localities. During the year 473 plaice were taken to the Devon bays. Twenty-three plaice were brought from the Barents Sea by a member of the staff on the steam trawler *Princess Louise,* and notwithstanding the great change in temperature experienced on the voyage, were liberated in apparently good condition in the North Sea. Twelve of these fish have been recovered, and were found to have grown at a rapid rate.

The following table gives the particulars as to the numbers of plaice recaptured during the year, with the exception of these twelve fish.

Year of Liberation.	Recovered from Ordinary Marking Experiments.	Recovered after Transplantation to Dogger Bank.	Recovered after Transplantation to Devon Bays.
Prior to June 1, 1906	4	13	—
June 1, 1906, to May 31, 1907 ...	25	96	—
„ 1907 „ 1908 ...	140	211	—
„ 1908 „ 1909 ...	293	49	30
Total	462	369	30

There have thus been recaptured during the year 861 plaice.

VITALITY EXPERIMENTS.—The plaice caught in ten hauls of the trawl, 3407 in all, were subjected to experiments designed to determine the length of time it is necessary to keep trawled plaice in circulating sea-water, in order satisfactorily to test their condition. While no period was found in all cases sufficient for such tests, the retention of the fish for twenty hours in the tanks, with periodic removal of dead fish, appears greatly to reduce the errors of experiment. A discussion of these experiments has been added to the report on the previous Vitality Experiments carried out by the Association, which has now been published.

B. LABORATORY WORK.

AGE AND GROWTH OF PLAICE.—During the last year a report has been issued dealing with the size and age of plaice at maturity in the North Sea and English Channel. A report has been in preparation dealing with observations on the age and size of over 19,500 plaice collected at different seasons and in different years over a wide area of the North Sea and in the western part of the English Channel. The ages of these fishes have been determined by examination of their otoliths or ear-stones. The investigation of this material has enabled the average size of plaice of given age on many different fishing grounds to be determined, and has brought to light some interesting differences.

Considerable pains have been taken to determine the true average growth of plaice in the region between the English and Dutch coasts, a task which is complicated by the circumstance that the size of plaice of the same age varies according to the distance from land. This difficulty has been overcome by determining the ages and sizes of all plaice caught in continuous lines of trawlings extending from the Dutch coasts into the open sea. The results of several series of observations along these lines agree very closely. They show, among other things, that the average growth of plaice in this region during the first three years is at the rate of 6–7 cm. a year; plaice of three years old averaging 20–21 cm. (about 8 inches) in length. In the western part of the Channel growth of young plaice is more rapid, the average length at three years old being 28 cm. (11 inches).

Plaice do not arrive on the Dogger Bank in any considerable numbers until they are about four years old. In the following year, judging from the average size of five-year-old plaice in this region, they grow faster than plaice of the same age in the southern and eastern parts of the North Sea. This observation is in harmony with the results of the transplantation experiments.

A somewhat sudden diminution in the average rate of growth takes place at the age at which the majority spawn for the first time. In the western part of the Channel these phenomena occur about two years earlier than in the central part of the North Sea.

An investigation of the proportions of the sexes at different ages in collections from the North Sea and English Channel has also brought to light interesting differences, which also appear to be associated with the age at which maturity first occurs in the two sexes in the two regions.

A comparison of the number of plaice of different ages caught per

hour with the trawl (1) in May and (2) in September at various distances along a line between Texel and the Leman Banks, has shown that the mass of each age group is situated further from the Dutch coast in the latter than in the former month. These observations distinctly indicate an off-shore movement of shoals of successive ages in the course of the summer, as has been shown by the results of marking experiments. These results thus confirm conclusions arrived at by Garstang (Internat. Investigations, Mar. Biol. Assoc. Report I, p. 93) from a study of the trawling investigations carried out by the s.s. *Huxley* concerning the source of the plaice found on the Leman Banks and Ground, and those of Redeke (Procès Verbaux, III, Ap. H) concerning the distribution of plaice off the Dutch coast.

TRAWLING INVESTIGATIONS.—The particulars of the trawling stations of the s.s. *Huxley* in 1904–5, illustrated by charts of the trawling courses, have been published, together with detailed measurements of the plaice caught in these years, and summaries, in 10 cm. groups, of these and other species of fish taken in each haul.

An examination of the catch per hour of plaice and dabs taken at the fixed trawling stations during 1908 with the otter and beam trawls, both partially covered by small-meshed net and uncovered, has been made, with a view to gaining information as to the constancy of action of each description of gear, and of the relative powers of capture of the otter and beam trawls. Catches from comparable hauls made in earlier years have also been examined, and the catches from day and night hauls made under similar conditions compared.

From this examination it appears that the day and night catches of plaice made by the s.s. *Huxley* in the North Sea as far north as the Dogger Bank do not differ appreciably. The comparative catching powers of the otter and beam trawls agreed closely with those arrived at by Garstang (Report on the Trawling Investigations, 1902–3, Internat. Investigations, Mar. Biol. Assoc. Report I, 1902–3, p. 74) for the action of these nets in the same region on a similar bottom.

EXPERIMENTS WITH SMALL-MESHED NETS COVERING THE COMMERCIAL TRAWLS.—The measurements of fish taken in trawls covered in whole or in part by small-meshed net have been tabulated. Eliminating twenty experiments in which the net was torn, a total of over 112,700 fish, taken in 118 hauls, have been treated.

In all these experiments the cod-end was covered, sometimes alone, sometimes with part of the batings, with all the batings, with the batings and square, or with all the trawl except the belly. The

following table shows the numbers of fish of various species dealt with:—

	Number Measured.		Computed.		Totals.
Plaice	12,565	...	—	...	12,565
Dabs	47,321	...	9,638	...	56,959
Haddock	21,070	...	—	...	21,070
Cod	1,136	...	—	...	1,136
Whiting	14,556	...	6,447	..	21,003
Totals	96,648	...	16,085	...	112,733

From a first examination of the results the following table has been drawn up, showing approximately for the various species the sizes at which 50 per cent of the fish are retained in the cod-end:—

	Otter Trawl.	Beam Trawl.
Plaice	—	10·5 cm.
Dabs	14 cm.	12 cm.
Haddock	19 cm.	—
Whiting	19–20 cm.	14·5 cm.
Cod	ca. 20 cm.	ca. 14 cm.

It will be seen that the beam trawl, which has a smaller mesh than has the otter, retains a larger percentage of the smaller fish.

Marking Experiments.—The plaice-marking experiments of the years 1906–8 are under examination. The results of these experiments confirm conclusions drawn from previous experiments made in the Southern Bight and on the Eastern Grounds, and add considerably to the knowledge of the movements of plaice on the Flamborough Off and adjacent grounds.

Invertebrate Fauna.—The report on the Invertebrate Fauna is approaching completion. The records have been classified in grounds whose delimitation has been carried out with reference primarily to the texture of the bottom, with, in the case of the larger grounds, subdivisions based on depth or average salinity, or made by arbitrary lines.

A study has also been made of the frequency of capture of the various species in the grounds chosen, and of the comparative importance of depth and texture in determining distribution in the North Sea.

Bottom Deposits.—A report on the bottom deposits is approaching completion. It is based on the examination of 568 samples, together with records obtained from material brought up in trawling and dredging. The distribution of various grades of deposit has been

studied, and a provisional division of the southern part of the North Sea into grounds on the basis of the textures of the bottom carried out.

Bottom Trailer Experiments.—The particulars obtained from the cards returned from Mr. Bidder's Bottom Trailer experiments have been arranged and analysed. Three new series of experiments conducted in 1906 have been examined, and three old series of 1904 and 1905 revised. The direction of the bottom currents and the approximate velocities have been ascertained. The series are mutually confirmatory in their indications. A very large number of the bottles have been recovered, 81 per cent of the cards from the first series having been returned. The percentage returned within twelve months of their being put out is between 50 and 60 per cent.

C. FISHERMEN'S RECORDS.

A report on the Lowestoft Trawling Records, dealing with plaice and soles, has been completed and published.

A report on the catches of plaice, soles, turbot, and brill by the Grimsby trawlers is approaching completion. The monthly average catches in different areas have been calculated and analysed. The report deals with 13,246 hauls, made from 1904 to 1907, during nearly 50,000 hours' fishing.

All these species are found to be relatively very numerous on the Eastern Grounds, off the Danish coasts, and to decrease rapidly from east to west, and all, with the exception of brill, show fairly regular seasonal variations in several areas. Plaice show an off-shore movement from the Eastern Ground in the summer, large plaice appear to migrate southwards in the winter, while small plaice disappear almost entirely from the catches at this time.

Soles show a very definite distribution. They are limited to the grounds south of a line drawn from the Horn Reef North Grounds to the neighbourhood of Flamborough Head. North of this line in the region investigated they are very scarce.

Turbot and brill have also been examined.

The records are now being examined with regard to the catches of cod, haddock, and whiting, and the monthly averages for the period 1904 to 1907 have been calculated for each area.

The records have yielded material for determining the relation between various statistical units, and factors connecting the rate of fishing per voyage, per day, per haul, and per hour have been calculated.

Section II.—HYDROGRAPHIC AND PLANKTON WORK IN THE ENGLISH CHANNEL.

In August, 1908, the southerly flow of comparatively fresh water from the Irish Channel was well marked, and the salinity at Station 4, near Parson's Bank, was much lower than in mid channel on the line from Plymouth to Ushant. Any division into layers of varying salinity was less than might have been expected during this month.

By November salinities had increased everywhere in the English Channel, and were nearly the same from surface to bottom. In the Irish Channel, however, the salter water normally found under the north coast of Cornwall had spread some distance seawards, under the influence of strong easterly winds, as a thin surface film.

Hydrographic investigations had, at the end of 1908, been carried out in the English Channel for six years, and had shown that the water eastward of Start Point is nearly always of the same composition from surface to bottom. In view of the fact that surface water samples are collected every fortnight on four cross-Channel steamers, it was decided to confine the work eastwards of a line drawn from Start Point to the Channel Islands to surface observations only, and to add seven other stations to the westward of the area usually investigated. Five of these new stations lie on the eighth meridian, and No. 37, the most southerly, is a short distance beyond the edge of the continental plateau. The depths here vary very irregularly, but soundings of from 400 to 500 fathoms are to be expected.

The February cruise of 1909 was the first made under the new programme. The water was everywhere nearly homosaline: at Station 37 the salinity was 35·53 °/₀₀ at all depths down to 450 m. (246 fthms.). Unfortunately the wire was not long enough to allow of observations below this depth, and no bottom was found.

The observations in the Irish Channel in May, 1909, show rather complicated conditions, a thick layer of salt water being here superimposed on one of lower salinity. It is probable that this distribution is due, as in November, to strong easterly winds.

At Station 37 the conditions were the same as in February, with the exception that the temperatures were slightly lower, and the surface layer had risen to 35·61 °/₀₀ salinity. On the bottom, however, which was not reached in February, the water had a salinity of 35·62 °/₀₀ and a temperature of 13°. The high bottom salinity has been noticed by several observers, and is generally attributed to a current from the Mediterranean. Until further confirmation is forthcoming, however, the high temperature must be considered doubtful, as it was measured

with a single reversing thermometer, and these instruments ought to be used in pairs, owing to their liability occasionally to give incorrect readings.

Samples of Plankton have been taken as usual on the quarterly cruises, and also at fortnightly periods on light-vessels on the southern and western coasts, and by the s.s. *Devonia* midway between Plymouth and the Channel Islands. Weekly samples have been taken at Plymouth.

The records of species caught on the quarterly cruises are published in the Bulletins of the International Council.

Zooplankton was very abundant in May, August, and November, in the Bristol Channel and around the Scillies. During May, Pseudo-calanus preponderated in the samples from this region. In August and November, Calanus was present in greater quantity at the western stations.

A new species of Tintinnus, which first appeared at E. 20 (off Start Point) in November, 1907, was found occasionally during May, August, and November, 1908, at isolated points from S.W. of Milford, through the English Channel, to the eastern stations, while a few specimens were taken in a netting from Longsands, in the North Sea, during August.

Noctiluca appeared off Milford in May, 1908, and was abundant in the Bristol Channel in August. It gradually spread eastward during November, and has been found very thickly distributed in the mouth of the Channel and at Plymouth during February and May, 1909.

During the year no less than five species of Ceratium, characteristic of warm seas, have been taken as far east as the Casquets area. Four were taken in February, 1908, west of Ushant. In May, one of these species dropped out and another appeared in its place. Two were taken in August and four in November. One species appeared off Milford in November.

Observations have been made on the food of Noctiluca, and records kept of the diatoms found in them at various times.

Published Memoirs.

The following papers, either wholly or in part the outcome of work done at the Laboratory, have been published elsewhere than in the official publications of the Association :—

Downing, E. R.—*The Connections of the Gonadial Blood Vessels and the Form of the Nephridia in the Arenicolidæ.* Biological Bulletin, vol. 16, 1909, pp. 246–258.

Gamble, F. W.—*The Influence of Light on the Coloration of Certain Marine Animals (Hippolyte, Wrasses).* Transactions Manchester Literary and Philosophical Society. January 12, 1909.

Goodey, T.—*A Further Note on the Gonadial Grooves of a Medusa, Aurelia Aurita.* Proceed. Zool. Soc., 1909, pp. 78–81.

Martin, C. H.—*Some Observations on Acinetaria.* Quart. Journ. Micr. Sci., vol. 53, 1909, pp. 629–664.

Donations and Receipts.

The receipts for the year for the ordinary work of the Association include the grants from His Majesty's Treasury (£1000) and the Worshipful Company of Fishmongers (£400), Special Donations (£273), Annual Subscriptions (£114), Rent of Tables in the Laboratory (£55), Sale of Specimens (£441), Admission to Tank Room (£120).

The following is a list of the Special Donations :—

	£	s.	d.
Colonel W. Harding	100	0	0
G. H. Fowler, Esq., PH.D.	25	0	0
E. T. Browne, Esq.	25	0	0
John F. P. Rawlinson, Esq., K.C., M.P.	21	0	0
A. E. Shipley, Esq., D.SC., F.R.S.	20	0	0
The Duke of Bedford, K.G.	15	15	0
W. Ambrose Harding, Esq.	15	15	0
E. Waterhouse, Esq.	10	10	0
Lord Avebury, F.R.S.	10	0	0
The Earl of St. Germans	5	0	0
The Right Hon. A. J. Balfour, M.P.	5	0	0
Professor A. Bevan	5	0	0
R. Gurney, Esq.	5	0	0
E. H. Parker, Esq.	5	0	0
F. G. Sinclair, Esq.	5	0	0
	£273	0	0

Vice-Presidents, Officers, and Council.

The following is the list of gentlemen proposed by the Council for election for the year 1909–10 :—

President.

Sir Ray Lankester, K.C.B., LL.D., F.R.S.

Vice-Presidents.

The Duke of Abercorn, K.G., C.B.
The Duke of Bedford, K.G.
The Earl of St. Germans.
The Earl of Ducie, F.R.S.
Lord Avebury, F.R.S.
Lord Tweedmouth, K.T.
Lord Walsingham, F.R.S.
The Right Hon. A. J. Balfour, M.P., F.R.S.
The Right Hon. Joseph Chamberlain, M.P.
The Right Hon. Austen Chamberlain, M.P.
A. C. L. Günther, Esq., F.R.S.
Sir John Murray, K.C.B., F.R.S.
Rev. Canon Norman, D.C.L., F.R.S.
Edwin Waterhouse, Esq.

Members of Council.

G. L. Alward, Esq.
W. T. Calman, Esq., D.Sc.
Prof. A. Dendy, D.Sc., F.R.S.
Sir Charles Eliot, K.C.M.G.
G. Herbert Fowler, Esq., Ph.D.
F. W. Gamble, D.Sc., F.R.S.
Prof. Walter Garstang, D.Sc.
S. F. Harmer, Esq., Sc.D., F.R.S.
Commander M. W. Campbell Hepworth, C.B., R.N.R.
E. W. L. Holt, Esq.
J. J. Lister, Esq., F.R.S.
P. Chalmers Mitchell, Esq., D.Sc., F.R.S.
Edgar Schuster, Esq., D.Sc.
Prof. D'Arcy W. Thompson, C.B.

Chairman of Council.

A. E. Shipley, Esq., D.Sc., F.R.S.

Hon. Treasurer.

J. A. Travers, Esq.

Hon. Secretary.

E. J. Allen, Esq., D.Sc.

The following Governors are also members of the Council :—

G. P. Bidder, Esq., M.A.
E. S. Hanbury, Esq. (Prime Warden of the Fishmongers' Company).
E. L. Beckwith, Esq. (Fishmongers' Company).
Sir Richard Martin, Bart. (Fishmongers' Company).
Prof. G. C. Bourne, D.Sc. (Oxford University).
A. E. Shipley, Esq., D.Sc., F.R.S. (Cambridge University).
Prof. W. A. Herdman, D.Sc., F.R.S. (British Association).

Dr. *Statement of Receipts and Payments for*

	£	s.	d.	£	s.	d.
To Current Income:—						
H.M. Treasury	1,000	0	0			
Fishmongers' Company	400	0	0			
Annual Subscriptions	115	9	0			
Rent of Tables	55	5	0	1,570	14	0
" Extraordinary Receipts:—						
Donations as per Report				273	0	0
" Charter of Steamboats:—						
S.S. *Huxley*, for half year	300	0	0			
S.S. *Oithona*, for special voyage	25	0	0	325	0	0
" Special Grant from the Fishmongers' Company made in advance to qualify Sir Richard B. Martin as life member of the Council				500	0	0
				£2,668	14	0

Examined and found correct.

(Signed) N. E. Waterhouse, A.C.A. Arthur Dendy.

W. T. Calman. L. W. Byrne.

30*th June*, 1909.

the Year ending 31st May, 1909. **Cr.**

		£ s. d.	£ s. d.
By Balance from last year, viz. :—			
Loan from Bank		700 0 0	
Less Cash at Bank	£437 5 7		
Cash in hand	18 19 11	456 5 6	243 14 6
,, Current Expenditure :—			
Salaries and Wages—			
Director		200 0 0	
Assistant Director		200 0 0	
Naturalist		175 0 1	
Salaries and Wages		639 0 2	1,214 0 3
Travelling Expenses			47 5 6
Library			101 6 5
Journal		132 11 3	
Less Sales of Journal		23 17 8	108 13 7
Buildings and Public Tank Room—			
Gas, Water, and Coal		107 12 6	
Stocking Tanks, Feeding, etc.		52 6 1	
Maintenance and Renewals		61 12 9	
Rent of Land, Rates, Taxes, and Insurance		39 17 8	
		261 9 0	
Less Admission to Tank Room		120 0 10	141 8 2
Laboratory, Boats, and Sundry Expenses—			
Stationery, Office Expenses, Printing, etc.		155 8 7	
Glass, Chemicals, and Apparatus	£160 6 10		
Less Sales	46 0 0	114 6 10	
Purchase of Specimens		55 14 4	
Maintenance and Renewal of Boats, Nets, Gear, etc, exclusive of s.s. *Huxley*	£173 14 9		
Less Sales	18 14 1	155 0 8	
Insurance of Steamers—			
S.S. *Huxley*	£215 11 3		
S.S. *Oithona*	20 13 7	236 4 10	
Coal and Water for Steamers, excluding s.s. *Huxley*		98 3 6	
		814 18 9	
Less Sale of Specimens, etc.		441 2 11	373 15 10
Bank Interest			14 11 8
,, Extraordinary Expenditure :—			
Purchase of s.s. *Huxley*—			
Second instalment of purchase price		150 0 0	
Interest on Loan		46 5 7	196 5 7
(The balance of the purchase price is secured by a Mortgage of the vessel repayable by annual instalments.)			
By Balance, including Special Grant of £500 per contra, applicable to the years ending 31st May, 1910 and 1911			
Cash at Bank		713 10 3	
Cash in hand		14 2 3	
		727 12 6	
Less Loan due to Bank		500 0 0	227 12 6
This Balance is apportioned as follows :—			
General Account	£ 49 11 2		
Repairs and Renewals Account	178 1 4		
	227 12 6		
			£2,668 14 0

An Experiment in the Transplantation of Plaice from the Barents Sea ("White Sea") to the North Sea.

By

George T. Atkinson,

Assistant Naturalist at the Lowestoft Laboratory.

About midnight on 26th June, 1908, at the close of a voyage to the White Sea fishing grounds, undertaken by Mr. A. E. Hefford and myself in the Hull steam trawler *Princess Louise*, H 837, Captain Turner of that vessel did me the great favour of taking a short haul to procure plaice for transplantation to the North Sea.

Object of the Experiment.—The object of this experiment was to test if it were possible for plaice to survive such physical changes as are necessarily involved in this great change of habitat, and to see further if they would display any feature of growth.

The result has been that not only do the fish appear to have survived, but they have grown in a most remarkable manner. The rate of growth shown by the last five specimens recaptured is much greater than that of North Sea plaice of the same sizes and sex, which have been marked in the same way and set out again on the grounds where they have been caught. The growth has been many times faster than that indicated by the otoliths of plaice in the portion of the Arctic Ocean from which they were brought.* This unusually rapid growth has been accompanied by considerable improvement of the fish as a marketable commodity.

The object of the voyage in the *Princess Louise* was to continue the investigations, commenced in the *Roman*, of the conditions of the plaice fishery in the Barents Sea.† It had been arranged to again accompany the *Roman*, H 948, but as Captain Leighton sailed a day earlier than was intended, he kindly arranged for Mr. Hefford and

* As an illustration of the extremely slow growth which obtains in these northern waters, I have in my possession a photograph by my colleague, Mr. R. A. Todd, of ten otoliths of as many fish of the VIII group (in these cases fish just nine years old), five of these fish are from the North Sea and five from the Barents Sea ; 47, 48, 52, 52, and 54 cm. were the lengths of the former, which were all mature females : the lengths of the latter three immature females and two mature males were only 30, 30, 32, 27, and 29 cm.

† *Journ. Mar. Biol. Assoc.*, VIII, 1908, p. 71.

myself to leave Hull with Captain Turner and to transfer to his own ship on the fishing grounds.

Unfortunately we were unable to meet as arranged, and this mishap deprived us of the use of two tanks which I had sent on board the *Roman*.* Had these been available a larger number of fish could have been as easily dealt with. To take the place of these tanks, there were improvised five tubs, made from halves of the casks which the trawlers take to sea for the reception of fish livers. Each of these was scrubbed out and filled with water to the depth of eighteen inches, holding in this manner 15–20 gallons apiece. Changes of water were effected by means of buckets and the use of the ship's hose at intervals. This primitive method was continued during the seven days occupied in steaming 1540 miles from the Barents Sea fishing grounds to the N.W. Rough of the Dogger, where the twenty-three surviving fish were marked and liberated.

A much larger number had originally been placed in these tubs, but owing to the very limited space available and the lack of means for adequately changing the water the mortality at first was very heavy.

We were fortunately favoured with moderate weather for the journey, except for some hours after coming out of the Norwegian fiords by the Lofoten Islands. Here the vessel, driven full speed in the face of a strong head wind, had the main deck frequently swept by the seas from the bows to the winch; however, the fish appeared to suffer no inconvenience and the tubs received no damage, being lashed on the after deck.

Besides my colleague Mr. A. E. Hefford, and Captain Turner, I have also to thank the chief engineer of the *Princess Louise*, Mr. Gardner, to whose resourcefulness in providing the tubs, and to whose interest, the successful issue of the experiment was in great measure due.

Changes of Temperature on the Voyage.—One of the most striking changes accompanying this journey south was naturally that of the temperature of the water in which the fish were being kept alive. On June 26th, on the fishing grounds, the bottom temperature varied between 34° and 35° F., whilst that of the surface was between 37° and 38° F. On June 27th, before reaching Nordkyn, the temperature was between 40° and 42·3° F., and on the 29th, at Tromsö, had risen to 45° and 47·0°, and reached 48·9° on the 30th, 49·5°–52·0° on July 1st,

* I suggested to Captain Leighton that he should on the following voyage attempt to bring back some living plaice in these tanks, and brought to his notice the precautions to be observed to obtain a successful result. In correspondence he informs me that he left the White Sea fishing grounds with about sixty fish, of which forty-two were alive on his arrival at the Humber. These were then iced and finally distributed amongst the members of the crew.

54·3°–55·7° on the 2nd, and on July 3rd, up to the time of setting out the fish, the temperature had ranged between 54·5° and 58·0° F. The extremes of temperature these fish experienced thus ranged over 24° F., without their appearing to have suffered from the rapidity with which the changes occurred.

Recapture of the Fish.—The following table gives particulars of the recapture of the individual fishes (see next page).

The object in selecting the N.W. Rough as the point of liberation for these fish was that, in addition to being in the direct track of our vessel between the Norwegian and English coasts, it was a ground which offered a fair prospect of some of the fishes being returned if they survived. Unfortunately some Grimsby, Hartlepool, and Scarborough trawlers, engaged in fishing for cod and haddock, chanced at once to visit the area of liberation, and in the first month eight fish were returned. Five more being subsequently recaptured gives the result that within one year 13 or 56·5% have been returned.

The latter five were caught in the fourth (two specimens), seventh, tenth, and eleventh months after liberation, and without exception show important and unusually rapid growths compared with those which have been observed in the case of North Sea fish of corresponding size and sex.

These growths were accompanied by considerable improvement in the condition from the point of view of the market value of the fish.

Movements of the Fish.—A feature connected with the movements of the last five fish is that all but one had migrated from the deeper water (33 fms.) in which they were liberated, short distances on to the Dogger Bank (20 fms. and less).

The furthest migrant was E 3880, which was taken on the Easternmost Shoal, about sixty miles from the point of liberation. Another fish, E 3876, had moved about forty miles in the direction of the Middle Rough and was retaken by a Dutch steam trawler. It is curious to note that the Grimsby trawler which effected the recapture of the former specimen also took, at the same spot, a plaice (E 778), which I had myself transplanted to the Dogger from the Dutch coast in May, 1907. This fish had grown 18·5 cm.

All the female fish brought from the White Sea appeared to be immature, the contrast between such and spent ones, so soon after the northern spawning season, being in most cases very marked without internal examination being absolutely necessary.*

* A new feature in the biology of the plaice lies in the enormous depth at which the Barents Sea plaice spawn. In May, 1909, Captain Leighton informs me, they were found by our trawlers to be in spawning condition in great masses in 90 to 106 fathoms.

TABLE I.

Table showing the particulars of liberation and recapture of the Plaice transplanted.

PARTICULARS OF LIBERATION.

July 3rd, 1908. 23 Plaice (E 3871–E 3893). Lat. 55° 8′ N., 1° 10′ E., 33 fms.
Transplanted from Barents Sea, Lat. 69° 0′ N., 41° 23′ E., 44 fms. ; carried 7 days in tubs ca. 1540 miles.

PARTICULARS OF RECAPTURE.

Date of Recapture.	No. of Label.	Locality Reported.	Depth (fms.).	Calculated Position.	Vessel and Port of Registry.	Original Length (cm.).	Ultimate Length (cm.).	Weight (grs.).	Sex and Maturity.	No. of Days at Liberty.
1908										
July 5	E 3873	Lat. 55° 14′ N., 1° 15′ E.	40	—	GY St. tr.	37·8	36·8	491	♀	2
,, 6	E 3887	Lat. 55° 0′ N., 1° 0′ E.	32	—	SH St. tr.	34·7	33·8	371	♂	3
,, 5–9	E 3889	(Found on Pontoon, Grimsby)	—	—	—	35·3	34·7	309	♂	ca. 4
,, 11	E 3881	Lat. 54° 58′ N., 1° 0′ E.	31	—	GY St. tr.	40·3	39·8	446	♂ sp.	8
,, 12	E 3883	Lat. 54° 52′ N., 1° 22′ E.	—	—	GY St. tr.	35·2	34·7	353g	♀ im.	9
a ,, 13	E 3874	75 miles E ½ S of Hartlepool	30	54° 54′., 0° 53′ E.	HL St. tr.	41·7	39·4 +	523	♀ im.	10
,, 20	E 3871	75 miles E ½ S of Hartlepool	28–30	54° 54′., 0° 53′ E.	HL St. tr.	35·6	35·1	407	♀ im.	17
,, 24–26	E 3890	(Found on Pontoon, Grimsby)	—	—	—	33·9	33·0	289g	♂ sp.	ca. 22
Nov. 6	E 3876	Lat. 55° 20′ N., 2° 20′ E.	20	—	Dutch St. tr. IJM	34·4	38·1	590	♂	126
b ,, 18	E 3880	Lat. 54° 39′ N., 2° 45′ E.	11	—	GY St. tr.	35·8	39·6	742	♀	138
1909										
Feb. 27	E 3884	Lat. 54° 50′ N., 1° 5′ E.	35	—	GY St. tr.	43·5	47·3	1095g	♂ sp.	239
May 14	E 3893	Lat. 54° 57′ N., 1° 20′ E.	18–20	—	GY St. tr.	33·9	39·9	702	♂	315
c June 20	E 3875	105 miles N.E. from Spurn	17–20	55° 5′., 1° 45′ E.	GY St. tr.	42·5	50·3	1535	♀	352

NOTES.

(a). Very stale. Tail rays damaged, probable length, 41 cm.

(b). Caught by same boat, on same day, and in same position as Plaice E 778. Apparently X years old.

(c). Very fat. Apparently commencing to mature for the first time. Noted "im. ?" on liberation.

Fish which have died or are still at liberty are E 3872 ♀ 44·4; E 3877 ♂ 34·6; E 3878 ♀ 36·7; E 3879 ♀ 33·0; E 3882 ♂ 34·1; E 3885 ♂ 37·3; E 3886 ♀ 27·8; E 3888 ♀ 39·3; E 3891 ♂ 35·7; E 3892 ♀ 46·4. It may be noted of these that slight abrasions were noted at the time of liberation in seven instances (70 %). Similar abrasions were nevertheless noted in six instances, 46 % of the fish which have already been recaptured.

All the males, on the other hand, were above the average size at which this sex is found mature in the Barents Sea; two were actually found to be spent on being returned to the Laboratory after a few days of liberty. This fact makes the growth observed all the more a matter of surprise, as we usually find large male plaice grow very slowly. *

E 3884, caught in February, was observed to be recently spent, and had thus taken part in one reproductive period in the North Sea. The ovaries of E 3875 were such as one observes in female plaice which are apparently maturing for the first time.

On the basis of these last five fish, as discussed below, it would be absurd to attempt to base any definite conclusions. In discussing them, the main desire is to bring to notice the suggestive results that this small experiment has attained, so that when the opportunity again arises similar experiments may be attempted on a larger scale, since it can no longer be doubted that a rational development of the plaice fishery of the North Sea would be possible under a carefully planned scheme of transplantations.

Below have been drawn up a few notes on the changes of which the last five fish returned have given evidence, regarded from the following points of view:—

1. Increase in size.
2. Increase in weight.
3. Increase in value.

1. Increase in Size.—The eight fish caught in July all show a slight shrinkage, as is usual in marked fishes retaken shortly after liberation. It is usual with some investigators to estimate shrinkage between death and remeasurement at 0·5 cm., but in order to depress the observed growths rather than to exaggerate them this convention has been disregarded throughout.

The two specimens reported in November had increased in length from (male) 34·4 to 38·1 cm., and (female) 35·8 to 39·6, or 3·7 and 3·8 cm. respectively. The next fish was retaken in February, and the growth from 43·5 to 47·3, or 3·8 cm., is a very rapid growth for such a large male. Another male fish came back in May, and had increased 6 cm., from 33·9 to 39·9 cm. The last fish returned gives an astonishing increase for so large a fish, having grown from 42·5 to 50·3, or 7·8 cm. (female).

* It is interesting to note in comparison with this experiment, that Strodtmann transplanted plaice from the Baltic to the Elbe L.V., making the passage to the North Sea through the Kiel Canal. These were chiefly mature fish, and though many were retaken very few had grown at all after several months in their new surroundings. Cf. Reichard, *Die deutschen Versuche mit gezeichneten Schollen II*, p. 34.

How rapid these individual growths are in comparison with those of the North Sea fish can be seen by reference to any published report. To illustrate this rapidity, a number of records have been taken from the English marking experiments in various localities in the North Sea. These have been put together in the form of a table, and fish have been chosen which mostly resemble the five White Sea plaice in original size, the sex being of necessity also the same.

At the head of each of five columns is given the label number of the White Sea plaice with its original size, growth, and number of days at liberty. Below each comes a list of North Sea fishes marked in the same way, and set out again in whatever part of the North Sea they happen to have been caught. Comparison can thus with ease be made by taking any of the North Sea fish and comparing the growth, or period at liberty, given at the top of the column:—

TABLE II.

Table showing growth in the periods stated of normal North Sea marked plaice to compare with five specimens transplanted from the Barents Sea.

E 3876 ♂ 34·4 grew 3·7 cm. in 126 days.		E 3880 ♀ 35·8 grew 3·8 cm. in 138 days.		E 3884 ♂ 43·5 grew 3·8 cm. in 239 days.		E 3893 ♂ 33·9 grew 6·0 cm. in 315 days.		E 3875 ♀ 42·5 grew 7·8 cm. in 352 days.	
Growth.	Days out.	Growth.	Days out.	Growth.	Days out.	Growth.	Days out.	Growth.	Days out.
0·4	83	1·7	116	0·0	110	0·0	82	0·4	143
−0·4	136	0·9	119	0·2	142	0·8	97	−0·2	148
1·4	141	1·0	121	0·3	162	3·5	112	0·1	176
1·0	142	1·0	154	0·8	230	2·4	119	0·1	197
0·7	195	2·5	156	0·9	286	0·3	123	1·8	212
1·9	196	1·0	183	1·3	293	0·6	142	1·1	234
1·0	252	1·8	193	0·3	314	2·0	262	0·7	282
2·6	292	2·5	272	0·8	321	0·2	267	0·7	296
3·0	273	5·5	277	1·1	340	3·4	287	1·6	314
4·4	275	3·1	361	0·5	365	4·7	315	2·0	326
1·9	293	4·9	373	0·5	410	2·5	338	1·8	350
5·4	453	8·1	618	3·1	676	1·6	453	4·3	353
0·3	481	10·0	649			4·3	462	1·4	360
1·2	506	4·1	802			3·1	613	1·6	414
						4·2	664	3·1	450
						1·0	694	2·5	458
						4·3	839	2·9	462
								2·1	469
								4·0	487
								1·3	489
								1·0	498
								6·5	510
								0·9	511
								1·4	556
								6·2	564
								5·0	596
								1·4	680
								5·6	781
All originally ♂ 34·0—35·0 cm.		All originally ♀ 34·9—36·5 cm.		All originally ♂ 39·0—42·7 cm.		All originally ♂ 33·0—33·9 cm.		All originally ♀ 39·0—44·7 cm.	

Although the above lists are not exhaustive and the growths quoted have been taken more or less at random, it can be clearly seen how slowly North Sea plaice of the stated lengths grew, as compared with these fish transplanted from the White Sea.

As compared with the first transplanted plaice only two growths of North Sea fish are noticed to be in excess, and these individuals had been at liberty respectively twice and three times as long after marking.

Comparing the growth of E 3880 with that of similar sized North Sea fishes, we find it only surpassed by specimens which have been out *twice, nearly thrice, four and a half, and nearly six times as long.*

No growth is observed to equal that shown in the case of E 3884, 3893, or 3875, though some of the periods of liberty are more than *twice* as long.

These growths are truly remarkable, in consideration of the probable age of the specimens concerned, and in view of the slow growth old plaice have been frequently shown to display.

It may be mentioned that further, but incomplete, investigations of the otoliths of the smallest plaice yet found on the White Sea grounds amply bear out the indications of slow growth afforded in my earlier report.

2. Increase in Weight.—All the fish have been weighed after their recovery by the fishermen, but, as the relation between length and weight of White Sea plaice in their normal condition is unknown at present, it is not possible to state exactly by how much the last five individuals have increased their bulk. In view of the additions which have been demonstrated as regards length, and in view of the fattened condition of the fish, the weight increments must have been very considerable. A tentative estimate can be deduced from the following data.

The weights of the eight fish caught in July compared with the average weight of Dogger plaice of the same sizes determined by Masterman* show deficiencies amounting to 17·3, 23·5, 41·5, 38·1, 29·1, 31·0, 22·9, and 26·8 per cent respectively. The average deficit amounts to just under 29%.

It cannot at present be said how closely this determination displays the actual deficiency in condition for which the White Sea plaice are noted, but it at least has the merit of bearing out the experience of practical men as to the inferiority of these fish as compared with those from the North Sea.

* Report on the Research Work of the Board of Agriculture and Fisheries in relation to the Plaice Fisheries of the North Sea. Cd. 4738. London, 1909.

I propose to estimate the increase in weight of the five fish referred to on two bases:—

A. That the original weight of each fish was equal to that of a normal Dogger plaice.

B. That the weights thus obtained (A) are on an average 29% too high, as was ascertained for the July fish.

Estimate A for the original weight being obviously too high, we can be satisfied that any increase shown on this basis is below that actually attained. It is further possible that increments based on Estimate B understate those actually attained.

The resulting figures are given in Table III below.

TABLE III.

Table showing estimated increase in the weight of five plaice transplanted from the White Sea to the North Sea, based on two estimates of their original weight.

A. That the plaice were equal in weight to Dogger plaice of corresponding sizes.

B. That estimate A gives an original weight value 29% too high in accordance with observations made on eight fish in July.

Number.	Estimated Original Weight.		Determined Ultimate Weight.	Increase in Weight.		% Increase.	
	A.	B.		Estimate A	Estimate B.	Est. A.	Est. B.
E.	grammes.	grammes.	grammes.	grammes.	grammes.	%	%
3876	485	344	590	105	246	21·6	71·5
3880	528	375	742	214	367	40·5	97·6
3884	843	599	1095	252	496	29·9	82·8
3893	405	288	702	297	414	73·3	143·7
3875	813	577	1535	722	958	88·8	166·0

From this table it can be seen that, on the lowest possible estimate, the two fish which had been at liberty the longest (and this period less than a year and including a winter) had increased by about three-quarters of their original weight (73·3% and 88·8%); the fish which had been at liberty shorter periods also displaying corroborative increments.

The data are too small to permit of further discussion, but by kind permission of my colleague, Dr. Wallace, I am able to put forward in contrast to the above figures data from his forthcoming report.

Dr. Wallace finds from otolith investigations that, as regards the plaice of the Dogger and Flamborough region, the weight of six-year-

old males (average size 37·0 cm.) shows an increment of less than 30% on that of those five years old, whilst the seven-year-old fish of this sex, having an average length of 38·1 cm., show less than 10% weight increment on fish a year younger. This oldest group is, however, not sufficiently well represented for this result to be regarded as more than approximate.

Dealing with the females, the six-year-old fish (average size 41·0 cm.) are found to average a little over 40% heavier than those of five years, and the seven-year-old fish (average size 44·1 cm.) show an increment of just over 20% as compared with the six-year-olds.

Referring these figures, which are based on abundant material, back to the percentage weight increments of Estimate A in Table III, the indications in this table present a truly remarkable contrast in favour of the probably older plaice transplanted from the White Sea.

3. Increase in Value.—The plaice fishery in the Barents Sea has only been conducted by our trawlers during four summers, and it would be premature to discuss the values of the product. These, however, have been adversely affected by two important considerations, the somewhat poor quality of the fish combined with excessive supplies in the summer months.

A trade expert giving evidence before the Committee on Fishery Investigations expressed an opinion that the plaice sell at less than one-tenth the value of any other plaice (*Committee on Fishery Investigations*, 1908. *Minutes*, *Cd.* 4304, *p.* 391).

The White Sea plaice have not the coarse, dark appearance, which used to characterize the old, accumulated stock at Iceland, and would, after a few months fattening in the North Sea, be indistinguishable in external appearance and doubtless too in food value from the indigenous population. Thus, if we may assume that each of the last five fish would have doubled its weight had it been at liberty a year, and basing the value of White Sea plaice at one-fifth that of North Sea plaice, each would have been worth at least ten times the price usually obtained.

It would be absurd, on the slender though corroborative evidence of the above results, to suggest that the transplantation of White Sea plaice would be practicable as a commercial undertaking. At the same time it must be admitted that even this would prove sounder economy as regards the development of the White Sea fishery than is the present plan of converting many tons of this valuable fish species into manure, as was done in the great gluts in the summer of 1909.

The fact that plaice can be carried in safety such long distances and through such varying conditions, broadens the question of trans-

plantation. Might not, for instance, plaice be carried across the Atlantic and introduced to the Canadian coasts and the Banks of Newfoundland, where its congeners in other waters, the cod, haddock, and halibut, already occur? Or, again, might not the very small halibut, which have been brought to market by the trawlers in vast quantities from certain parts of Faxe Bay, Iceland, also be brought alive and set out on the North Sea grounds, where this valuable species was without a doubt much more abundant formerly than it is to-day? Such, and many practical questions of a similar nature, proffer a wide field for future research.

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